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From L'Illustration

Heavy Artillery of Great Power Employed on the French Front

BATTLING BOTH NIGHT AND DAY

Present Day Problems of Plant Geography—I*

As Related to the Necessity for Intensified Production

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THE war has caused a sudden rupture in the equilibrium of the organized world. The present problem of phytogeography is to substitute for the equilibrium which has been destroyed the new equilibrium imposed by novel conditions—the vastest problem which this science has ever been compelled to solve.

In order to assure the future of our economic life it appears to be essential that production should be intensified in territory now under cultivation, that devastated territory should be restored and that neglected land should be made available. To achieve these results with certainty it is necessary to ascertain the plants best adapted for each locality, and to determine the most favorable environment for any given plant. "In order that we may plant no tree at random, and sow no seed by chance," to quote Senator Chauveau, "we must first determine whether one or the other has a chance of surviving in a given region. And how can we have precise knowledge in this respect except by previously acquired information as to their geographical distribution—information which shall give us an idea of the climate they require, of their biology, of the conditions of their customary environment, of the associations they form with other plants commonly found in the same milieu."

We must first study, therefore, the conditions of the environment with respect to their influence upon vegetation, from the ecologic point of view.

I.

ECOLOGY

Ecologic factors may be grouped according to the following table:

PHYSICAL FACTORS

Climatic.—Temperature, humidity of atmosphere, light, wind.

Edaphic.—Temperature, humidity, chemical composition of soil.

Physiographic.—Physical structure of the Geosphere and of the Hydrosphere (altitude, exposure, declivity, topography).

BIOTIC FACTORS

Influence exerted by plants upon each other (bacteria and algæ of the soil; mycorhizas; parasites; plants which support and plants which shade). Influence exerted by animals (fauna of the soil; insects which procure pollenization; animals which secure distribution of species or which contribute to their destruction).

Influence exerted by man (human manipulation; facts of cultivation).

CHRONOLOGIC FACTORS

Geologic.—Ancestral, geological and paleological conditions.

Historical,—Ancient distribution of plants and the history of their succession.

§ 1.—CLIMATIC FACTORS

The unequal distribution of radiation is the dominant cause of the unequal distribution of plant species. The richness of plankton in Diatoms is in direct ratio with insolation: luxuriant in the spring, planktonic life shows up with the increasing light and heat of summer.[1]

The rapid growth of plants in high altitudes and latitudes is to be explained doubtless by the action of the ultra-violet rays.[2]

The extension of each species on the surface of the earth is limited, first, by a definite amount of heat, second, by a certain minimum temperature for winter, for summer and for spring.[3]

It is the *severe cold of winter* which limits in the North the cultivation of such plants as lucerne, red clover, fodder cabbage, winter vetches and maize, which make the fortune of temperate regions.

When the cold totally destroys a certain variety of lucerne, it follows that 100% of the individuals of this variety are too delicate. If the destruction is only partial a certain number of plants are able to resist it, and these are called hardy.

Experiments on the experimental farms of Canada have shown that hardiness is a *hereditary* characteristic, and that it belongs to *individual* plants of a variety. It is possible therefore to increase the hardiness of a variety, or, in other words, to increase the number of hardy specimens by the elimination of all the types which are too delicate, and the multiplication of the resistant types.

Since nature eliminates the delicate types the cultivation for improvement undertaken by man consists simply in the propagation by seed of those plants which survive after the feebler have been destroyed.

What we call a variety is in fact a mixture of several varieties and types, presenting divers degrees of rusticity. Mr. O. Malte has isolated[4] nine elementary varieties of red clover whose hardiness—determined by the number of plants which resist the winter—varies from 53% to 2%.

Test of Red Clover at Ottawa in Two Lots

First Lot

	Number of plants			
	Autumn 1913	Spring 1914	% of rusticity	Yield of hay per acre
Variety 1	622	333	53.6	13 tons
Variety 7	562	81	14.4	10 tons
Variety 9	432	9	2.1	0.1 tons

Since hardiness depends largely on where the seed comes from, cultivators have reason to seek seed raised as far North as possible.[5] Intense cold in winter, during the period of rest, is less harmful to plants than a few hours of cold in the spring when the buds are formed. Hence the necessity of protecting vines, fruit and vegetables against late spring frosts has engaged the attention of producers. Besides *artificial clouds* (coal-tar smudges, etc.) long used by vine growers to diminish radiation, heating by fire-pots to raise the temperature of the ground and surrounding atmosphere is now practised by the English and the Germans, following in the footsteps of the Americans.

The great American horticulturists employ heaters or stoves burning crude petroleum or coal. In Indiana an average plant, capable of raising the temperature 10° F. (5.5 C.) costs about 640 francs per hectar.[6]

Violent winds warp the tops of trees; on the Provence littoral the mistral prevents the branches of trees from developing except along the seashore; "they express by their manner, by their attitudes, by their strange gestures, the proximity of the great tyrant, and the oppression of his blast . . .; they gaze upon the ground, turning their backs to the enemy, they bend . . . and twist in the wind of the storm" (Michelet).

The deformations described result from two very different phenomena: eotropic curving of organs and premature mortification.

R. Morquer observes, referring to the experiments of Kny and of Hartig, that when a branch is curved its flexion exerts a pressure upon the tissues of the concave surface, where the protoplasm reacts by a more rapid growth. Dr. Lalesque confirms this in his report of recent observations of sections of maritime pines curved by the wind on the Landaise dunes, stating that in all the trees exposed to the west wind the annual libero-ligneous ring is much thicker on the eastern side, on the concave surface,[7] than on the the convex surface towards the west.

The branches shaken by the wind injure each other when they clash together[8] and the leaves, subjected to an exaggerated evaporation,[9] are dried.[10] In sandy regions the grains of sand raised by the wind are like volleys of shot from machine-guns fired at plants and giving them mortal wounds.[11]

Sudry has shown[12] that "there is a continuous trend of sea salt from the ocean to the land caused by the wind." The spray which the wind snatches from the waves and deposits and concentrates on littoral plants forms a hypertonic solution on the surface of their organs, which, penetrating by the stomata, dehydrates the parenchyma and plasmolyzes it.[13] The cellular water which this saline coating extracts from the leaves is lost by the active evaporation caused by the wind: equilibrium is constantly interfered with, the leaf dries, flattens, and is reduced to its two epidermal surfaces.

The protective tissues nearly always remain intact, and the plant can sometimes protect itself by closing its stomata, through which the plasmolyzing solution enters and by increasing the molecular tension of the cell sap of the parenchyma, as we have seen to be the case in the needles of the maritime pine. The presence of starch would seem to be indispensable.

The wind is the agent also which brings down upon plants the fumes and smoke from industrial centers,[14] the dust of roads[15] and at present the toxic gases employed by the German army.[16]

§ 2.—PHYSIOGRAPHIC FACTORS

Altitude, latitude, proximity to the sea or to large sheets of water or to mountains or masses of forest, the orientation and slope of the ground, and natural or artificial shelter, are physiographic facts. They act upon vegetation indirectly by their influence upon the various meteoroligical phenomena of which the general or local climate is the result.

In high latitudes the length of the days in summer compensates and more than compensates for lack of heat, and vegetation is very rapid. At Fort Resolution, in latitude[17] 61° 14′ spring wheat matures in 116 days; potatoes planted May 22 are mature on September 22, a month sooner than in the maritime provinces of South Canada.

The *slope* of the ground, which gives vineyards of the coasts such an advantage over those of the plain, affects, together with orientation, all plant growth; agriculturists know this—they commence sowing their wheat on north and east slopes about the tenth of October and finish on the southern slopes at the end of the month.

Large bodies of water prevent the drying of the atmosphere and regularize the temperature, especially by diminishing nocturnal precipitation.

The lakes of Neuchâtel and Geneva reflect the rays of the sun during the day on the only vineyards of Switzerland, and insure them a sufficiently high temperature during the night. The seas and oceans act in the same manner: a higher temperature of both earth and atmosphere, and a greater rainfall cause

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*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Revue generale des Sciences (Paris).

[1] J. Pavillard: Researches on the Pelagic Diatoms. *Stat. Zool. Cette*, Nov., 1916.

[2] J. Escard: Electro-cultivation: *Rev. Gén. des Sciences*, Vol. XXIV, p. 302. Vide: Radium and Vegetation. *Vie Agricole*, Vol. VIII, p. 374, 1916. We know that the radiation of preparations of radium reduces the period of rest in winter buds and can be employed for the forcing of plants.

[3] The vine, for example, demands, according to Angot, 2,800 deg. C. for its annual development; in this calculation only *useful* temperatures should be considered, comprised, in a single season, between the relative maximum and minimum of the species under consideration.

[4] Reports of Ottawa Experimental Farms, 1916.

[5] The use of seeds coming from the South produces doubly disastrous results. Besides lacking hardiness the seeds are hard and germinate poorly. The dry heat exaggerates the development of the mechanical zone of the integuments, which interferes with the penetration of the water required for germination. To secure the germination of Sulla, whose seeds are hard, the Arabs fire the stubble upon which they are sown; the fire roasts a portion of the seeds, but those in which only the hard envelop is destroyed germinate more readily. The hardness of the seeds forms an obstacle to the introduction in France of species from our colonies.

[6] The installation should include an alarm thermometer interposed in the circuit of a battery; a platinum wire penetrates at the contact of the mercury column at 0°C., and a second penetrates beneath. The circuit is broken and a bell rings when the mercury falls below 0°C, (32° F.).

[7] In budding pines, it is in the side towards the East, called the abrupt face of the wood, that resin collectors recommend the greatest care. Vide F. Lalesque: Scientific and Medical Notes upon Arcachon (in press).

[8] Borggreve: On the Effect of Storms, 1873.

[9] Hansen: The Vegetation of the East Friesian Islands, Darmstadt, 1901.

[10] Brock on Injury to Leaves by Wind. Bot. Centralblatt, 1906.

[11] J. Massart: The Conditions of Existence of Trees in Littoral Dunes. *Bull. Soc. Centr. Forest de Belg.*, 1904.

Paletzky: Fixation of the Sand on the Trans-Siberian Railway. Petrograd, 1901.

[12] Sudry: *Ann. Inst. Océanog.*, vol. IV., f. 4, 1912.

[13] J. Dufrenoy: Injurious Action of the Deposit of Marine Salt on Littoral Plants. *C. R. Soc. de Biologie*, vol. LXXIX., No. 17, Nov. 4, 1916. See also *Rev. Gén. des Sc.*, p. 699, Dec. 15, 1916.

[14] V. Sabachnikoff: Effects of Smoke and Dust upon Vegetation. *Rev. Gén. des Sc.*, Feb. 28, 1914.

[15] C. L. Gatin has shown that the deposit of coal-tar dust on leaves prevents the storing of reserves of starch. (The Application of Coal-tar to Roads and its Effect upon Neighboring Vegetation. *Am. Sc. Nat.*, 9th Series, vol. XV., 1912, and also: Trees, Shrubs, and Forest Undergrowth, P. Lechevalier, Paris, 1913).

[16] P. Viala: *Acad. d'Agric.*, May 24, 1916. In the forcing houses of Bailleul the dew-covered vine leaves have been scorched by the chlorinated gases; the leaves in the heated green-houses whose surface was dry, suffered no lesion, but their vegetation was arrested for 8 days. Mr. Viala has reproduced the lesions observed on leaves which he sprinkled with Javelle water.

[17] R. P. Duport: *Report of Experimental Farms*, p. 884, Ottawa, 1916.

an earlier harvest in plants of the littoral (H. Dupuy), permitting the cultivation on the coasts of Brittany and Algiers of early crops.

The proximity of the sea has no direct specific action upon flora.[11] The fact noted by Cloës that every plant living on the seacoast accumulates more salt than when growing inland is without significance.

The great quantity of salt (Na Cl) contained in the ashes of littoral plants comes not from the tissues themselves, but from the salty deposit made by the wind on their surface (Péligot).

Moreover, the halophytes do not grow on the littoral because proximity to the sea is necessary to them but because, on salty earth, and in air loaded with salt spray, which only they can stand, they do not fear the rivalry of the species which drive them from the interior. The wild beet grows on the coasts of Europe in all latitudes and all soils. It is found in the saline clays of the dikes of the Arcachon reservoirs, in the quartz sands of the Landaise Dunes, in the Senonian cliffs of the Pays de Caux, but only where no other plant will spring; on the edge of the cliffs of Etretat one will seek it in vain among the herbs of the meadows that cover the silicious clay; but where the bare chalk crops out, entirely sterile, it sinks its tap root into the slightest fissures of the rock. And in gardens, where man defends it from adventitious herbs, it readily acclimates itself far from the sea.

"Quite independently of the climatic character of the region," writes Dr. F. Lalesque, "every mass of forest land possesses its own peculiar character, with its own formula: climatologic, climatophysiologic, climatotherapeutic."[12] Forests exert a cooling and moderating influence on temperature. They temper climates by diminishing the intensity of severe cold and extreme heat. Inspector E. Cuif of Nancy,[13] shows that the frigorific action of a resinous forest (pines) is more marked than that of a deciduous one.

In his works on Climatology Dr. Lalesque has noted the drying power of the maritime pine, its rapid conquest of marshy lands, whose healthfulness it measurably improves, and its action on the bacteriological and chemical nature of the air by the superabundance of ozone and of vapors of turpentine.

Forests form a screen, *par excellence*, against the wind and slashings should "always run counter to the most dangerous prevailing winds, in France going from N.E. to S.W.,"[14] in order to protect the growing plantations and especially the old trees standing in an isolated position. Wooded islands should be reversed, arranged in checker-board fashion, in order not to form gullies where the wind could have full sway. The primary aim in reforesting should be the constitution of wind-shields running at right angles to the prevailing winds.[15]

Much has been written regarding the reforestation of high-lying mountain valleys, but it has not been sufficiently emphasized that trees are needed on the crests of hills to ensure the humidity required by fields and vineyards on their flanks. Without the forests of the Great Mountain of Reims, which enable the vine to prosper there, the great vineyards of Mially, Verzenay, Verzy would be uncultivated hills of chalk.[16] The deforestation of the crests has ruined the valley of the Garonne at many points; the vines which yet remain cling to the slopes still dominated by clumps of trees or a few cypresses.

Deforestation and reforestation, therefore, exert a very great influence on local climate, affecting the agriculture and the viticulture of the region.[17] In a general fashion, and aside from the facts of parasitism and epiphytism, plants influence each other profoundly by mere proximity.

§ 3.—BIOTIC FACTORS

Isolated the tree preserves a coarse thick form, adapted to the struggles it must sustain against bad weather. In the forest, protected by the vegetable society which assures it a peaceful existence, it needs struggle only against its compeers.[18] The trees of equatorial forests have very straight trunks, rising 20 meters (65 feet) before the first branches spring.[19] The graining is straight in the direction of the fiber of the wood without the spots and figures caused by knots and whorls in the walnut trees of Europe.

The height of trees[20] and the orientation of the production are much affected by the density of the plantation.

To produce the maximum yield each plant must be allowed a certain surface area. It is the extent of this required surface that agricultural experiments seek to determine, bearing in mind, however, that dense plantations are less subject to parasites and to weather mishaps.

The relative arrangement of the plants is another factor to be considered, whose study has been hardly begun. The agricultural experiment station at Tambow (Russia) demonstrated in 1914 that equal quantities of seed sown in rows produces a better yield than broadcast sowing.

Even the orientation of the rows has its own measure of importance.[21] In the valley of the Garonne hedges of maize surround and protect the tobacco plantations. Fields of maize are protected by hedges of vines or shrubs. Finally we have ourselves[22] shown the value of windbreaks of old trees.

In France clover is often sown among oats, which act as a plant shelter; when the oats are densely planted this practice lessens the future yield of hay by 2.5% (Langelier).[23]

Directly, by choking cultivated plants or starving them in the struggle for existence, and indirectly, by toxic action, by favoring the propagation of parasites, and by increasing the labor of harvesting,[24] adventitious herbs or weeds caused, before the war, a loss of a billion francs per year to French agriculture.[25]

What a frightful tribute they will exact now, after several years of the poor cultivation incident on the conditions and when hundreds of thousands of hectars remain fallow!

Intensive culture consists mainly in the struggle against spontaneous vegetation, to insure by artificial means the survival of domestic species which are productive, but less robust. Before the war weeds were the chief obstacle to agricultural progress; it was the impossibility of weeding and separating in good season which prevented the extension of sugar beet cultivation in our various provinces.

In the future the struggle against weeds must be made by chemical means, rather than mechanical ones,[26] and biological rather than chemical. Here again "only life can struggle against life" (Marchal): It is by the cultivation of *robust aggressive plants, especially well adapted to the soil and the climate*, that the farmer will triumph.[27]

Every plant is a weed, in fact, which is out of place in the distribution of crops. But adventitious plants often prevail because ecologically they are in the right place where they are growing; and it is the crop which the agriculturist is trying to establish which is not so.

Among the spontaneous plants in clayey ground which wage a bitter fight with cereals we find particularly good forage species (hybrid and white clover, lotus, meadow-grass, bent-grass, bat-grass, etc.). It is very stupid, therefore, to regard as weeds plants of high fodder value which can readily be transformed into meat via pasturage.[28] Instead of fighting them laboriously by weeding they should be cherished. "Considering the advantageous price of meat and the great expense of cultivating clayey ground," concludes M. Schribaux, the best thing to do is to turn these into pastures."

Coordinated effort on the part of the agricultural population, exerted upon ecologic factors, is capable of considerably increasing the production of a country. But when individual human action does not further the general interest, and still more when this is injured by bad government,[29] the richest land may be turned into a desert. We know what the Turks, those devastators of forests, for example,[30] have made of rich provinces of their empire. Syria once supported a populace ten times as large as now, and in the sixteenth century Mesopotamia cultivated an area as large as that of Great Britain.[31]

Hunter, shepherd, then agriculturist, man has always been obliged to control natural phenomena, in proportion as he has formed increasingly dense groups, in order to intensify plant production.[32]

But the knowledge of the ecologic environment, the resultant of the factors which we have enumerated or studied, is necessary to all culture, indispensable to all progress. It enables us to select the plant species fitted to it for a given natural locality. It also enables us to construct for a given crop the necessary artificial conditions (remedies or improvements for the soil, shelters, hot-houses . . . fermentation industries.[33] Above all it enables us to make use of variations in plants to further improvement in crops.

[TO BE CONCLUDED]

The Nearest Star

HERETOFORE we have called *a Centauri* the nearest star, but now we have to give that position to a faint star near *a Centauri* which is apparently moving through space with the latter but somewhat nearer to us. This star was referred to in a note on p. 556, Vol. XXV of *Popular Astronomy*. In *Circular* No. 40 of the Union Observatory, South Africa, Mr. Innes gives the result of a determination of the parallax, from micrometric observations connecting the star with an 11.7 magnitude star 30″ distant. From these measures alone the resulting parallax is 0″.802, but Mr. Innes combines this with the result obtained by Dr. Voute 0″.755 and another value 0″.796, obtained from the ratio of the proper motions of this star and *a Centaur*, and adopts for the final parallax 0″.782.—*Popular Astronomy*.

[11] L. Daniel has come to the conclusion, from experiments which he has been pursuing since 1900, that "plants transported from Rennes to Erquy (Côte du Nord), on the border of the sea, have not acquired any characteristics of halophyte vegetation during 15 years of exposure to the influence of the spray and intermittent sprinkling with salt water; and that the only definite variations are those caused by the very pronounced variations in the condition of the water supply (quantity, quality, and saline concentration), occasion dwarfism and gigantism; this action is purely temporary."

[12] F. Lalesque: Forest Cases.—Report of International Congress of Physiotherapy, Paris, 1910.

[13] *Bull. Soc. de Sc. of Nancy*, p. 226-309; 1914.

[14] Jolyet:—Treatise on Sylviculture, 1916.

[15] C. R. of Congress of French Association for the Advancement of Science, 1912.

[16] Pacottet: Viticulture, Paris, 1912, p. 70.

[17] When the forest masses are elevated and of large extent (Vosges) they emit a cold humidity which descend upon the vineyards at night and make certain the development of cryptogamic diseases and the rotting of the grapes. With the same altitude and latitude, and a similar exposure, the vineyards of Alsace, dominated by the Vosges, yield wines inferior to those of the Palatine vineyards, situated at the foot of the low hills of the Harx (Pacottet: *loc. cit.*). The principal vineyards of the Basin of Arcachon were frozen and perished in 1800 when the forestation of the littoral dunes cut off the warm winds from the ocean which had heated them (Abbé Petit: The Captalat of Buch: *Biolog. Stat, of Arcachon*, 1909).

[18] E. Cardot: Tree Manual.

[19] F. Roguet: French Equatorial Africa, vol. I, p. 6, Colonial Office, 1916.

[20] Lumbermen deprived by the war of the slender trunks in the dense forests of the North have made active search in the Southwest for the tall trees which bad management has allowed to grow tall in pine forests too closely planted, and which would normally have no value. The *Pignadas* of the Landes domains are complete and homogeneous plantations organized for the production of wood; in some instances they are thinned to allow a distance of as much as 6 meters (cc. 20 feet) between the "place pines" and produce a great deal of resin. (J. H. Ricard: In the Landaise Counrty.)

[21] Influence of Orientation of the Rows upon the Soil: Researches on Sugar Beet. *Revue Gén. des Sc.*, p. 329, June 15, 1915.

[22] J. Dufrenoy: Eventual Bringing into Production of French Territory, *Ibid.*, Aug. 30, 1916.

[23] The yields obtained by employing for plant shelters, peas, barley, wheat, oats, are respectively proportionally to 3.8, 3.4, 3.1, 2. (*Experimental Farms*. Ottawa, 1916, p. 243).

[24] The weeding of flax costs 0.125 francs to 0.15 francs per 30 handfuls, according to the quantity of thistles.

[25] Schribaux: *Acad of Agric.*, Jan. 17, 1917.

[26] Mechanical treatment should be given at the same time as manual cultivation by powerful implements such as the American disc harrows.

[27] A better study of the biology of weeds would also be useful (Fron; Plants Injurious to Agriculture, Bailliere, 1917).

[28] It is regretable to observe that for most good clay soil farmers buy inferior commercial seed grain (Ray-grass, feather-grass), substituting these in their made pastures for superior and better adapted spontaneous species. Moreover, this is an abuse of pasture land which causes the disappearance of the best spontaneous species, for the benefit of the poor plants, which survive only because the animals refuse them.

[29] In Turkey the peasant who cannot pay the tax is not allowed to harvest his crop, he must let it rot on the stalk (*Nat. Geog. Mag.*, Washington, 1914).

[30] The trunks of cedars 3 or 4 hundred years old in the Atlas are left lying after being felled—since there are no highways of communication only the branches can be carried off mule-back. Hence fuel is scarce in the plains and coal sells as high as 200-300 francs per ton in Asia Minor. (R. Trowbridge: *Nat. Geog. Mag.*, Washington, Dec., 1914).

[31] T. N. Carver: The Probable Effect of the European War on the Redistribution of Population. *Scientia*, I-II. 1917.

[32] Dr. R. Dubois: The Rotatory Antikinesis. *C. R. Soc. Biol.*, Nov., 1915, and Jan. 8, 1916.

[33] Before the war the setting of French and Belgian flax of prime quality was done exclusively in the Lys, whose waters were regarded as endowed with peculiar qualities. However, after careful studies made upon the spot, M. Feuillette was able to reproduce experimentally in his factory at Goderville (1914) the same ecologic conditions provided by the Lys for the micro organisms concerned in retting.

His retting vats operate the year round at a constant temperature of 24°C; the retting is complete in 6 days; 10 workmen handle annually 1500 tons of flax. The season for treating flax in the Lys lasted from May to October and 12,000 hands were required to treat 100,000 tons of flax (the harvest of the preceding year). One workman who handles 10 tons in the Lys handles 150 tons in the Feuillette factory.

Canada offers us a new example of the application of ecologic data. In its humid drying-rooms the moulding of tobacco caused extensive losses. The tests of the Tobacco Service (*Rep. on Exper. Farms*. p. 1149) made(in the Province of Quebec during the rainy autumn of 1915, proved that the invasion of mould can be succesafully combated, and desiccation accelerated by the use of charcoal burners; and also that the proportion of light-colored leaves, much desired, is thus increased.

The New German Schreckliche Gun

CONSIDERABLE excitement has developed over the sensational 76-mile gun with which the Germans have been conducting a desultory, aimless and useless bombardment of Paris, and the affair has been surrounded by much mystery of various discussions in the daily papers—"Munchausen business" as this class of matter is colloquially known among newspaper men. But, although the distance covered by this gun is undoubtedly a record, it has been very clearly shown by an article that appeared in the SCIENTIFIC AMERICAN of April 6th that the methods by which this has been accomplished, and the principles of construction of the gun have long been known to, and are well understood by artillerists of all countries. Of course we do not as yet know anything about the details of construction of this gun; but that is a matter of minor importance, and the Allies would find no great difficulty in constructing similar weapons if they were deemed desirable or necessary.

The practical problems relating to the Schreckliche gun, for that is the only practical purpose it serves, are so thoroughly covered in the article in the SCIENTIFIC AMERICAN which is referred to above that they will not be repeated here. It may be interesting to our readers however, to cite some historical facts that give an idea of how long the principles involved in the German gun have been understood, and to describe some early experiments made in this country. It is not, however, to be understood that the facts stated constitute either the earliest endeavors, nor the only ones.

Somewhere about 1880 A. S. Lyman, of New York, the inventor of the well known Lyman Sight, so widely used on sporting rifles, devised what he termed an "accelerating gun," the purpose of which was to impart a very great velocity to the shot, not only to increase its range, but also its striking power; and in trials of a 2½-inch gun built on this principle, made against a 5-inch Whitworth (English) gun, it demonstrated that it gave a much greater penetration at short ranges. In other words, it developed superior velocity in the projectile.

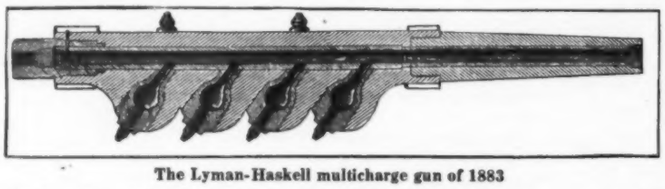
About this time Col. J. H. Haskell became associated with Mr. Lyman, and, after making a number of improvements, a gun of the new design 24 feet, 11½ inches long, and having a bore of 6 inches was built in 1881 for further trials. An illustration of this Lyman-Haskell accelerating, or multicharge gun, shows the general construction of the gun, and will make clear the explanation of its principles.

It was clearly recognized that in order to attain a great range a correspondingly great velocity must be imparted to the projectile, and this resolved largely into the amount of explosive used to propel the shot. In those days, on account of the character of the material available, the amount of pressure that it was safe to develop in the gun was limited, and it was the object of the Lyman-Haskell inventions to overcome the results of this limitation. It may be incidentally remarked that even today, because of the wonderful improvements that have been made in explosives, we are still unable to avail ourselves of the full power of the most powerful modern explosives in our guns, but we have learned, very possibly as a result of the experiments of these inventors, how to control and utilize our explosives in a way that meets all practical requirements.

In the construction of the Lyman-Haskell gun provision was made for burning a greatly increased amount of powder, but doing this in instalments, so that a high, but not excessive, pressive was maintained in the gun from the time the projectile started until it left the barrel of the gun, instead of attempting to apply the power of the explosive by a single very powerful explosion. This was accomplished by providing a series of powder pockets connecting with the bore of the gun at intervals. An initial charge of powder, of moderate size, was first exploded in the breech of the gun, in the regular way, to overcome the inertia of the projectile, and start it on its way. Then, as the shot passed the openings of the auxiliary powder pockets, their contents were fired consecutively. In this way it was anticipated that a velocity of 4,000 feet per second would be imparted to the projectile.

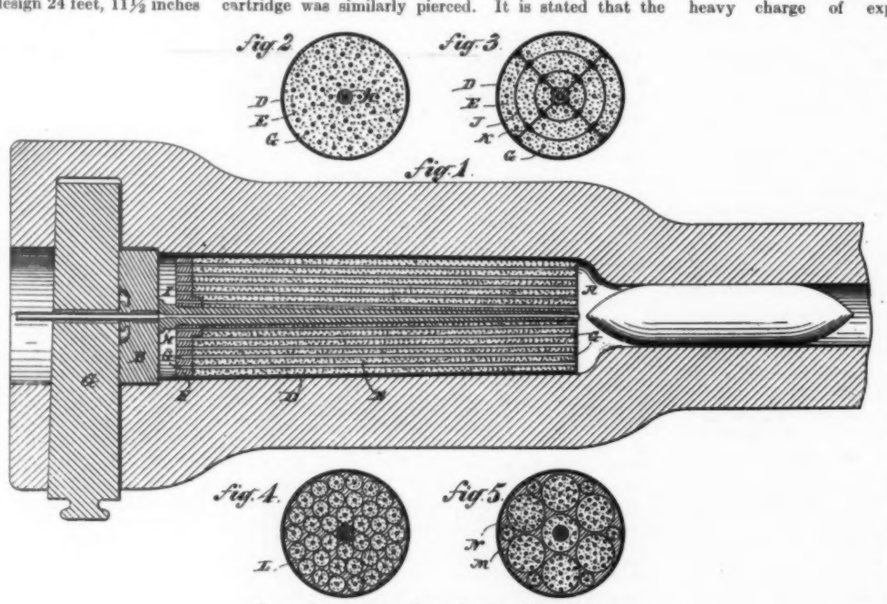
In the Lyman-Haskell gun it was expected to use 130 pounds of powder, and to throw a projectile of 150 pounds; whereas the regular six-inch guns of that day fired only 34 pounds of powder behind a shot weighing from 60 to 75 pounds. The velocity of the shot fired from these guns averaged about 1,500 feet per second.

The expectations of the inventors was not realized, although they attained a velocity of over 1,700 feet by the use of 84 pounds of powder; and it is possible that their failure may have been due to the fact that their gun did not have a sufficiently long barrel to fully utilize the power developed, although the gun in question was extremely long for its day. And it is further possible that a longer gun was not tried because the technical facilities of that day were not equal to the task of building it.



The Lyman-Haskell multicharge gun of 1883

Subsequent events would indicate that difficulties were experienced in controlling the firing or combustion of the various charges of powder in the multo-charge gun, for we find Mr. Lyman filing an application for a patent for a cartridge of original and unique design in January, 1885. This patent was issued June 30th, and is numbered 321,374. The drawings accompanying this patent are shown herewith, and it will be seen that it is intended to use this cartridge in a gun having a greatly enlarged powder chamber, so that a much greater quantity of powder can be used than in the ordinary gun. This cartridge was composed of powder, or other explosive material, as the patent states, packed in a dense, solid mass or cake within a shell, or case, and this powder cake was pireced by holes running longitudinally through it from end to end. The base of the cartridge was similarly pierced. It is stated that the powder is preferably packed in the shell in a soft or plastic state, and allowed to dry and harden in the cartridge; but the powder cake may be formed outside the shell and afterwards inserted therein. It is also stated that the cake should be hard and dense, so that the fire cannot penetrate into it, but must burn only on its surfaces, as distinguished from masses of powder of granular structure.



Lyman's compressed powder cartridge of 1885

"To fire the cartridge, a flame is forced down the firing-tube and ignites the front end of the powder-cake and flashes back down the perforations in the powder-cake, igniting the surfaces of all the holes at the same instant. The fire-surfaces at this moment are comparatively small, and the pressure is correspondingly low; but as the burning proceeds in a radial direction the holes in the powder-cake become constantly enlarged and the fire-area continuously increases, as also does the pressure upon the projectile, and the inertia of the projectile is gradually and slowly overcome. After the projectile has been started from its seat and as it passes through the gun the pressure exerted upon it is substantially maintained by reason of the continuously extending fire area, and this continues until the powder-cake is substantially all consumed, it being the design to construct the cartridge so that the powder will be almost consumed before the projectile reaches the end of the bore. In this way a comparatively low maximum pressure may be substantially maintained upon the projectile for the greater part or the whole of the time it is passing through the barrel of the gun, the effect being to relieve the walls of the gun from dangerous strains, and to give the projectile a greater velocity and effective power than is accomplished by cartridges of common construction."

It is also stated that the pressure developed in a given gun, with a given projectile may be varied by altering the form of the powder-cake; and that is possible with this kind of cartridge to get a pressure that shall continuously increase from time of ignition till the holes in the cartridge are burned through.

It will be seen from this description that this patent discloses the fundamental principle embodied in the form in which modern high explosives are prepared for use in big guns, as seen in the cylindrical cakes, perforated by longitudinal holes; and hexagonal cakes with one or more perforations, a large number of these being packed in a cartridge to form a charge of a size not anticipated at the time of this invention.

In the patent drawings Fig. 1 shows a cartridge that has a firing tube that conducts the fire from the primer to the front of the powder cake, but it was also proposed to ignite the cake at its rear end, if desired. Fig. 2 is a cross section of the cartridge, where D is the case; E the compacted powder and G indicates the longitudinal perforations. Fig. 3 shows a cartridge for very large guns, and has a reinforced, or sectional case. Fig. 4 shows a cartridge made up of a number of small cylinders containing powder cakes packed in a large outer case, or shell. Fig. 5 shows a similar cartridge formed of a number of perforated cakes of different size.

The method by which the Germans are enabled to throw their shells into Paris from a distance of in the neighborhood of 76 miles depends on the use of, 1, a sufficiently heavy charge of explosive, properly controlled; 2, a gun having a barrel long enough to utilize the force of the explosive; and 3, the elevation of the gun to the proper angle. It will be seen from the foregoing that these principles have been well understood for many years. In some quarters it has been surmized that the original projectile fired from the gun is of considerable size, and is itself in the form of a cannon, containing a smaller projectile which is fired from the larger shell after the latter has traversed a portion of the distance. This may be the case, as nothing seems impossible now-a-days, but it is not considered probable as the ultimate course taken by the second projectile would seem too uncertain to recommend the scheme. It may be said, however, that even this idea is by no means new. There are a number of other theories in regard to this German gun, some of whom are discussed in the current issues of the SCIENTIFIC AMERICAN, to which such of our readers as may be interested are referred.

Identification and Determination of Zinc in Water

Two hundred c.c. of the water is treated with 1 c.c. of concentrated hydrochloric acid, evaporated to 80 c.c., and 1 c. c. of concentrated ammonia is added; the precipitated iron and aluminium hydroxides, if present, are filtered off, dissolved in a small quantity of hydrochloric acid, reprecipitated with ammonia, and again filtered off. The combined filtrates are diluted to 100 c.c. in a graduated cylinder, and 2 c.c. of concentrated ammonium sulphide is added. If, after the lapse of 15 minutes, a distinct opalescence or turbidity develops, zinc is present in the water and its quantity may be determined by comparison with the turbidity produced by a known amount of zinc under the same conditions. The method will detect about one part of zinc in 100,000 parts of water.—Note in *J. Soc. Chem. Ind.* on an article by R. MELDRUM in *Chem. News*.

Anomalies of the Animal World—Part IX

Anomalies to Be Found Among Ordinary Birds

By Dr. R. W. Shufeldt

WHEN an ornithologist applies the term "ordinary" to any species of bird, he refers to one which is normal in all particulars, presenting nothing in its anatomy, appearance, nidification, habits or other characters but what is most usual in birds as a rule. Such a bird is seen, for example, in our common chippy or chipping sparrow. Everything about a chippy is decidedly ordinary. In appearance and plumage it is strictly so, as are likewise all its habits. Chippies build medium-sized, concave, pretty little hemispherical nests, lined with hair, on the upper side of some small limb, and lay a regulation clutch of blue eggs which are sparsely speckled. The young are ordinary in all particulars, and reared by their parents in the most ordinary manner possible. In fact, as stated above, our little chippy with its simple song, plain and modest plumage, and regular migratory habits—everything and all about it is strictly normal and ordinary.

There are a great many birds in the North American avifauna that depart no further than chippies do from a certain set of fixed habits, characters and characteristics. What we see in that species holds true for many another species of small *land* birds, while it is departed from, in one way or another, by birds representing other groups of different families. For example, what we would find in the ordinary little land-bird which we call a chippy would be quite different in a duck, a woodpecker, a gull, and so on. Yet we have *ordinary* birds in all of those groups, and in fact there are, *sui generis*, ordinary birds in nearly all avian families. Where such is not the case, they are found among the "outliers," and then present unusual characters for the reason that they are the only species of their kind remaining in existence, and we come to regard anything about them as anomalous.

A good example of this is seen in that big terrestrial falcon of certain parts of Africa, called the Secretary-bird from the elongated feathers at the sides of its head, suggesting a quill behind the ear—a custom of writers among our forefathers. This long-legged representative of the falconine assemblage—or diurnal Raptores—is the most unusual form of that group living, and deserves to be reckoned among anomalous birds.[1]

Then, among the Passerine birds, there may be cited as a good example the species called the *Huia* by the native Maoris of New Zealand, where the form has its habitat.

Newton says: "According to the personal observation of Sir. W. Buller, who enters at length on the natural history of the *Huia* (*Birds of New Zealand*, second edition, vol. I., pp. 7-17), its favorite food is the grub of a timber-boring beetle, and the male bird with his short, stout bill attacks the more decayed portions of the wood and chisels out his prey, while the female with her long, slender bill probes the holes in the sounder parts, the hardness of which resists his weapon; or when he, having removed the decayed portion, is unable to reach the grub, the female comes to his aid and accomplishes what he has failed to do. The *Huia* is entirely a forest bird, and is doubtless one of those doomed to extinction, though at present it seems to maintain its existence."[2]

These *Huia* birds are surely not of the kind we might call ordinary birds, but very striking examples of distinctly anomalous forms.

[1] Shufeldt, R. W. Some of the "Outliers" among birds. *Pop. Sci. Monthly.*, Vol. XLVI, No. 6, N. York, April, 1895, pp. 760-780. Figs 1-10

[2] Newton, Alfred, *Dict. of Birds*, part ii. p. 438. The Huia bird is figured in this article, and it may be said that early in the history of its discovery, owing to the fact that the bill is entirely different in the two sexes, the male and female had been referred to as two distinct species.

Some our our smaller United States land birds are extremely ordinary in all particulars, save perhaps one, and that excepted one is distinctly anomalous. Take, as an instance, the well-known Cowbird, also known by numerous other vernacular names as the brown-headed Black bird, the Cowpen-bird, the Cow-bunting, and so on. A popular writer on the habits of birds at hand says of this species: "The singular habits of this bird, shared by others of the genus, form one of the most interesting chapters in ornithology. Like the European Cuckoo, it builds no nest, laying its eggs by stealth in nests of various other birds, especially Warblers, Vireos and Sparrows; and it appears to constitute, furthermore, a remarkable exception to the rule of conjugal affection and fidelity among birds. A wonderful provision for perpetuation of the species is seen in its instinctive selection of smaller birds as the foster-parents of its offspring; for the larger egg receives the greater share of warmth during incubation, and the lustier young Cowbird asserts its precedence in the nest; while the foster-birds, however reluctant to incubate the strange egg (their devices to avoid the duty are sometimes astonishing), become assiduous in their care of the foundling, even to the neglect of their own young, which usually perish in consequence. The Cowbird's eggs hatch in 10 or 11 days, and thus sooner than that of most birds; this obviously confers additional advantage. The list of birds in whose nests Cowbirds' eggs have been found is now about 100, and includes a large number of Finches, Warblers, Chats, Greenlets, Wrens, Larks, Thrushes, Gnatcatchers, Flycatchers, etc.; there seems to be really little choice. While *small* species are usually victimized, this is not always the case; we have found eggs in nests of the Kingbird, Towhee, Robin, Bobolink, Marsh Blackbird, Brewer's Blackbird, yellow-headed Blackbird, various Orioles, red-headed Woodpecker, yellow-billed Cuckoo, and Carolina Dove."

Yellow-billed Cuckoo (*Coccyrus americanus;* adult male) from life by the author

Speaking of the anomalous habits of Cuckoos with respect to their propensities to lay their eggs in the nests of other birds, it may be noted that all of our United States species and subspecies *occasionally*, though it better be said rarely, resort to this habit, in so far as other species are concerned; while upon the other hand, it is not at all uncommon for them to thus victimize the several species of their own genus. For example, our yellow-billed Cuckoo will lay its eggs in the nest of our black-billed species and *vice versa*. Many years ago it was my fortune to find the egg of a yellow-billed Cuckoo deposited in the nest of a robin; and, although they most frequently build a loose, shiftless nest for themselves, they are also prone to drop their eggs in the nests of the Catbird, Mourning Dove, some of the Sparrows and Warblers, and so on. Where, however, the habit of parasitism, in the matter of incubation, is most pronounced is among the Cuckoos of the Old World.

This has been described over and over again in natural history stories and in technical ornithological works, so that nearly every intelligent Anglo-Saxon child is more or less familiar with the story. Moreover, the modern moving-picture machine has thrown the entire operation on the screen in such a vivid manner of late that many, who had never heard of it before, know something of it now.

Both in the matter of *plumage* and *flight*, the common European Cuckoo mimics the Sparrow-hawk—a mimicry quite essential to its peculiar parasitic propensities.

In selecting the foster parents for its young, the *male* Cuckoo will hover over the nest containing the rightful owner's eggs. Fright at once seizes the former, and they sally forth to drive away the intruder, whereupon the *female* Cuckoo slips in and drops her egg in the temporarily deserted home. Strange to relate, the eggs of the Cuckoo mimic in *color* and *markings* the eggs of the selected foster-parents, even in such extreme cases where the eggs are *blue*, as is the case with the Redstart—a species frequently victimized by the Cuckoo.

When hatched, the young cuckoo—while still nearly featherless and with eyes still closed—will insinuate itself in turn under each young bird in the nest with it, worry it upon its back, and then deliberately cast it overboard, whereupon it falls to the ground to perish in one way or another.

This is the story in brief, though it might be made more instructive and interesting by the addition of many of the minor incidents in this most anomalous and extraordinary procedure.

Another species, the Great Spotted Cuckoo of Northern Africa and Southern Europe, not only lays eggs which closely resemble those of the foster-bird, but, instead of being satisfied to lay *one* egg in her victim's nest, lays from two to four. When the young are hatched, they at once begin to fraternize with the rightful occupants of the nest—a scheme that is invariably successful, and results in the foster-younglings receiving just as much attention at the hands of the foster-parents as their own brood.

In the case of the Koel Cuckoo of the Polawan Island of the Philippine group, it invariably selects the Myna-bird as the foster-parents. This is a *black* species that have, when hatched out, black-plumaged young. In the case of the Cuckoo only the male is black, while the female is *brown;* and when that is the case among birds, the young usually assume the plumage-coloration of the female—a rule that is reversed here. For when the Mynas hatch out the young Cuckoos with their own brood, it will be noted—another wondrous avian anomaly—that the young cuckoos wear a plumage of *black!*

In the subadult individuals of this Cuckoo still another rule is reversed; for the females at this stage possess a *black* plumage, and do not don the brown one of the adult females until after the first moult. As there are a great many species of Cuckoos in the world, a book might be written upon their anomalous habits and characters.

In the matter of the propagation of their species, still more wonderful birds are the numerous species of Brush Turkey or Megapodes occurring in the Philippines, in Nicobar Island, and in Australia and Samoa. These are large fowls, in some ways resembling a turkey. Instead of incubating their eggs, the females help each other in constructing great mounds of decaying vegetable matter, or use certain mounds of sand—the former often being reared to a height of eight feet, possessing a circumference of over 60 feet. They are added to from season to season, and in them the female digs a cavity in which to deposit and then cover her eggs. She lays one every second day. Subsequently the engendered heat of the nest material hatches these out; when lo! another wonder is at hand, for the young

are full-fledged, and fly off in less than an hour after emerging from their eggs.

Another anomaly, coming under the head of incubation, is seen in the case of the Albatross, wherein, as Professor Mosely informs us, the egg is held in a sort of pouch found on the abdomen of the female. Mr. Dudley Le Souëf, the Director of the Zoölogical Gardens of Melbourne, Australia, has secured most excellent photographs of the female Albatross, showing her egg partly protruding from this pouch. In so far as my knowledge carries me, no other bird possesses a similar anomaly.

The male Hornbills of the East Indies, of which there are several species, seal up the females during the period of incubation in hollows of trees until the young are hatched, the latter at first resembling ellipsoidal bags of jelly more than the nestling of anything in the bird world. Wallace says, in his most interesting book, "The Malay Archipelago": "The extraordinary habit of the male in plastering up the female with her egg and feeding her during the whole time of incubation, and till the young one is fledged, is common to several of the large Hornbills, and is one of these strange facts in natural history which are 'stranger than fiction.'" (p. 147.) The whole story of Hornbill incubation as now known, is, however, a long and most interesting one, but would require an entire chapter to itself to relate. Mr. Charles Hose of Borneo has given us a mass of details on the subject.

Hundreds of species of birds there are to exemplify anomalies in habits and notes. The males of a South American species of *Manakin* go through a most extraordinary dance, selecting some bare twig for the purpose. It is indulged in by a pair of males at a time. They face each other on this twig, something over 18 inches apart. The dance is of clockwork regularity, the birds alternately jumping up in the air, about two feet at the jump, the one starting as the other alights, the performance being accomplished by peculiar and somewhat musical notes.

One of the birds starts by crouching down on the limb, and, uttering the clear note "to" springs into the air; when at the height of the spring pipes the note "le," and on coming down and landing again, completes the accompaniment by a pensive "do—to-le-do." As the first bird alights, the second pipes his "to," passes through the same performance, and lands on the twig as the first again starts with his "to." The regularity of the dance is marvelous, and the pair continue it until both are exhausted.

Few birds possess a more remarkable note than the Bellbird of the Brazilian forests, of which some four or five species have been exhausted. They are found only in the densest of those tropical forests and are not frequently seen. Their loud, sonorous note has been likened to the tolling of a bell, or to the sounds produced by a blacksmith striking his anvil in regular rhythm. Males of three of the species are pure white in plumage, with vividly colored skin of the face, and a skin-process hanging down from the center of the crown, but capable of being erected at the will of the bird. This appendage is thinly covered with feathers.

Space will not admit of describing here any more of the many remarkable dances and singular notes of the curious species of birds in various parts of the world; the subject may be closed by passing reference to the "Screamers," which are but little known South American birds, the size of a small turkey. They are related to the swan-duck group, though a representative of them has more the general appearance of some large fowl or other—a cross between a big game rooster and a gray goose! The screamers have the remarkable habit of banding in small flocks composed of a number of individuals. These take wing and soar to immense altitudes, and when up in the air so high that they can scarcely be seen by the unarmed eye of man, they are heard to utter the loud, screaming notes to which they owe their name. Sometimes they gather in immense flocks to go through with these performances; for instance, Mr. Hudson informs us that the Crested Screamer at one time astounded him by "an awful and overpowering burst of melody," which saluted him from half a million of voices at an out-of-the-way spot in the pampas one evening at nine o'clock; and, again, once at noon he heard a flock take up their song round the entire circuit of a certain lake, each flock waiting its turn to sing, and only stopping when the duty had been performed.

Sometimes a peculiarity of a very common bird will escape observation for years. Woodcocks and snipes, for example, possess the power of altering the form of the distal extremity of superior mandible of the bill. This alteration consists in having that end assume a form similar to the free extremity of one of the jaws of the surgeon's bullet-forceps, when the jaws are parted distally to seize a bullet deeply imbedded in the flesh. This arrangement is of great use to a woodcock, or a snipe; for in *probing* for worms in a stiff soil, they can readily seize them, after they have been detected by the sensitive ends of the beak, by the aforesaid dilating of the end of the upper mandible in the manner described.*

Turning again to the avifauna of South America, we find a most remarkable bird, anomalous in more ways than one, inhabiting the dense forest trees of British Guiana and elsewhere. This is the *Opithocomus cristatus* of science, and known as the Hoatzin or Hoactzin in the vernacular. This species has already been briefly noticed in a previous chapter of this book (Flightless Birds), where the fact was pointed out that the adults of the species possessed but very limited power of flight. They simply pass from limb to limb in the big trees in which they live, and which overhang the sluggish rivers of that country.

Anatomically, the Hoatzin is remarkable in a number of particulars, as it has a skeleton and digestive apparatus altogether different from any other known species of living bird. Some of its Indian or native names mean a stinking-bird, which my old correspondent, Mr. Quelch, who has studied the Hoatzins in the British Guiana forests, says they well merit. This peculiar odor is like the raw hides of cattle or wet musk, and is very powerful and penetrating.

Adult Hoatzins are curious birds enough, but they are not any more so than their nestlings or young. These, as soon as they are hatched, have a rather downy appearance, with a marked lengthening of the tail. Almost as soon as they are out of the egg, they *crawl* out of the nest in the most remarkable manner, for not only can they use their feet for the purpose, but the *claws of the hands*, and their very serviceable beaks, the latter having all the power of a small pair of forceps. In this crawling about among the twigs of the tree upon which their nest is situated, the *claw of the thumb* comes especially into use for the purpose.

When the parents approach with food, these young Hoatzins energetically and quite dextrously crawl through the twigs to meet them, and when thus progressing, they would surely remind the thoughtful naturalist of what the locomotion of the long extinct Jurassic bird, *Archæopteryx*, must have been like. In the latter, however, the claws and fingers of the adult were better developed than in these Hoatzin nestlings, although the mode of progression would be the same. It is not difficult to imagine how the young of the *Archæopteryx* would get about among the twigs of a tree, taking hold with their beaks, and using their hands and feet, while their long, flexible, skin-covered tails of some 21 caudal vertebræ, with the row of elementary "pin-feathers" down each side, dangling behind them.

In the young Hoatzin the quill-feathers borne by the thumbs do not develop until the necessity for the use of the claws on that digit has passed; in other words, their development is checked till the others have grown of sufficient length to serve the purposes of flight.

An adult Hoatzin is about as large as an average game hen; in fact, there seems to be a gallinaceous vein in its anatomical makeup, and it may be a very aberrant form of that group, with some other strain or two besides in its organization. Without doubt many of the earliest ancestors of birds, when adult, used their hands just as young Hoatzins employ them today up among the dense forest frees that overhang the banks of some of the great rivers of Guiana.

When we come to study the question of "protective mimicry" in birds, such as is afforded by the plumage and form in a large number of species throughout nature, we pass to a field of observation, the data of which hardly falls legitimately within the scope of this chapter, or even of this book, to discuss. Nevertheless, certain structures are sometimes developed in birds that not only serve to "blend" them, sometimes, with their surroundings, thus rendering them less likely to be observed by their enemies or by the casual passer-by; but these structures are likewise quite anomalous of their kind owing to their very unusual character.

A single example of this must suffice here for the purpose of exemplifying what is meant by such an anomaly, if an anomaly it be. It may be illustrated by certain African species of Nightjars (birds like our Nighthawks and Whip-poor-wills), the pennant-winged Nightjar, that possesses a wonderful development of the second primary feather of either wing. This, in adult individuals, attains a length of seventeen inches or more. The "shaft" of one of these feathers is for the most part bare, while the "vane" is developed spatulate fashion, at the extremity. When flying this bird looks as though it possessed *four* wings, while when it alights on the ground amid long, delicate grasses, some bearing *feathery ends*, these curious feathers stick up perfectly straight, but wave in the wind like two shoots of the surrounding grass, the bird resembling a small stone of the ground between them.

*Shufeldt, R. W. "On the Mechanism of the Upper Mandible in the *Scolapacidæ*." The Ibis, London, Oct. 1893, pp. 563-565. 2 figs.

Our Wasted Resources

In his presidential address at the annual meeting of the American Society of Civil Engineers, Mr. George H. Pegram made a strong presentment of the waste of some of our great natural wealth, which should appeal to every citizen of our country. He said:

"With the greatest heritage of natural wealth in all the world, we are most prodigal and wasteful in its use. We have the largest supply of coal of any country, and, knowing that civilization itself, in a modern sense, depends upon the coal supply, we are told that in the short space of 200 years, if its consumption increases at the present rate, our coal will be exhausted. What a brief period compared with the 5,000 years of recorded history of China, which, with a coal supply next in size to our own, imports coal. The conservation of this mineral devolves upon the engineer, not only in the improvement of machinery with which its power is applied, but in the utilization of water power, the improvement of natural waterways, and the construction of canals, by which transportation costs can be lessened.

"Eighty years ago, or within the lives of many now living, the canals of the United States, more than 2,500 miles, exceeded the railways in length. It was then possible to make the trip by water, completely around the eastern part of the country, from New York to Buffalo, by river and canal, thence to Cleveland by lake, to the Ohio River by canal, and thence by river to the Gulf.

"An English engineer, writing of New Orleans at that time, said: 'At every hour, I might almost say, every minute of the day, magnificent steamboats which convey passengers into the heart of the western country fire off their signal guns and dash away at a rate that makes me giddy to think of.'

"At that time there were boats on the Mississippi River with a capacity of more than 1,000 tons, which exceeds the capacity of any of the present boats; and, subsequently, boats with a capacity of more than 3,000 tons were operated.

"Previous improvements of our rivers have been piecemealed; we have aimed at quick results instead of conforming to a comprehensive scheme. Navigation has faded away in regions where millions have been spent to preserve it. Flood lands which, by proper regulation of the river and by the deposition of sediment, might have been built up, have been protected by expensive levees which have prevented the natural process of reclamation. Floods which should be impounded for service in dry times are allowed to run to waste.

"We are taught that the mouth of the Mississippi was once at Cairo, more than 1,000 miles from the Gulf, by the river, and that the great fertile valley was formed by alluvial deposits. These alluvial deposits are not only needed to raise the surface of the land, but are very rich in fertility. We have leveed the river so that the sediment is deposited in the Gulf, where it is not only lost to land building but entails constant labor in jetty-building and dredging to keep the mouth of the river open to navigation. The levees are being built higher and higher at great cost, and the lands they are designed to protect are being eroded and their fertility exhausted. This would seem to be a problem where the engineer might 'direct' the forces of Nature for the 'use and convenience of man' instead of opposing them.

"Man is the only animal that invents. He can thus change his environment, which in turn re-acts to change him. We rise from purely animal conditions by the aid of invention. We can sink back by its loss. Little do they realize, who claim that labor produces all wealth, how paltry would be the results of labor without invention and design."

The Crater of Vesuvius

Since the eruptions on Mount Vesuvius on December 26th the floor of the crater has risen on an average about 35 to 50 feet in the section from northwest to northeast. A new and very active eruptive cone 130 feet high has been formed in the western side of the old cone, and streams of lava, flowing underground under a large tract of the crater, issue from the northwestern extremity, forming a dome of lava now nearly 50 feet high.

The Hypo Scarcity—What To Do About It

According to our information the present scarcity of hypo is not so serious as to amount to a famine. Floating supplies are undoubtedly small, but no doubt photographers generally warned by previous shortages have taken the occasion to provide themselves with stocks sufficient to tide them over such periods as the present. At the same time there is the shortage and the question requires to be answered how it shall be best dealt with with a view not merely to the present juncture but also to that of similar happenings in the future. Before dealing in turn with several points we would be allowed to say that one thing which most certainly should not be done is to scamp the use of hypo and thereby to issue prints the permanency of which is a question of weeks or months. It would be a thousand pities that the shortage of an essential material should prompt such a course as this. Photographs at the present day enjoy a deserved reputation for a very fair degree of permanence. It would be far better to make them very much more costly things than to endeavor to make an insufficient supply of hypo go round by stinting its use.

It must be remembered that there is no workable substitute for hypo in the fixation of plates or prints; and there is no substance which can be added to hypo in order to make it "go further." Additions such as ammonium chloride (sal ammoniac) have the effect of making a fixing bath quicker in action, but they do not allow of a larger number of plates or prints being fixed with a given weight of hypo. Therefore a photographer's consideration at the present juncture requires to be of the practical ways and means which can be adopted for reducing wastage of hypo. Apart from such sheer waste as occurs in handling the solid chemical—which we think is negligible and may be at once put on one side—wastage of hypo consists in discarding fixing baths before they have done as much work as they are capable of. How then are baths to do more fixing work without prejudice to the quality and permanence of the results? Broadly, there are four ways in which a fixing bath, as it is commonly used, could be better employed. These are:

(1) Rinsing between development and fixing.
(2) Testing for degree of exhaustion.
(3) Passing on print fixers for use with plates.
(4) Keeping at suitable temperature.

These provisions apply broadly both to negatives and prints, but their application is naturally more in respect to prints, for the reason that prints occupy a much larger proportion of a photographer's output and call for more careful supervision as regards fixing. We will now take these four points in succession and endeavor to indicate simple procedures which photographers and their assistants can and should adopt as a means of economy in the essential hyposulphite.

(1) *Rinsing after development.*—This applies particularly to prints, since rinsing the developer from the surface of a print very greatly reduces contamination of the hypo bath by developer, with its effects of stain and, in aggravated cases, of muddiness in prints. In the case of papers such as bromide, which are fixed in a plain, as distinguished from an acid, bath, the omission to rinse prints before placing in the fixer will often cause the hypo bath to develop a strong color long before its fixing powers are approaching exhaustion. Plainly, economy in hypo will result, under these conditions, from cleansing the prints from developer before they go into the fixer. In the case of prints of the gaslight type, which usually are treated in an acid fixing bath, a brief wash-off of developer is in a somewhat different category. With some gaslight papers it is essential to use an acid fixing bath, and when that is the case there is not much advantage in rinsing after development. In fact, some papers will not stand such rinsing but yield yellow stains unless plunged immediately into the fixer. On the other hand, some gaslight prints will bear fixing even in a plain hypo bath, and at the same time will not suffer by receiving a brief rinse between development and fixing. We advise photographers to discover for themselves just what the brand of paper which they are using will allow, and then, if practicable, rinse between development and fixing; also, again if practicable, fix in a plain instead of an acid bath. Hypo in plain solution goes further than in any other form.

(2) *Testing Exhaustion.*—In the case of plates, we can see for ourselves by the slowness with which they clear that the fixing bath is nearing the end of its tether; in the case of prints no such evidence is afforded, and it is here that some working test is necessary to show how the fixing bath is getting on and to avoid discarding it whilst it still retains ample fixing powers. A test of this kind which anyone can apply for himself is as follows:

A few ordinary dry plates—any make, any grade, are cut up into slips of, say, one inch width and three or four inches length. It doesn't matter whether the plates are fresh or stale, nor is it a question of any great importance whether they have been exposed to daylight before being used for the test. Preferably they should not be exposed more than necessary. Our own practice is to cut up the plates by a bright yellow light in the dark-room and then to keep the slips (without any wrappings) in a plate box. The exposure to light which they get in the print-fixing room, when taking out a single slip, will not do any harm. One of these slips is then put into the fixing bath, which has been in use for a larger or smaller number of prints, and a note taken of the time required for the white emulsion to dissolve out. If this time requires to be longer than ten minutes the bath may be discarded, at any rate for fixing further prints, and it may be said that the test, rough as it is, is a pretty fair indication that hypo in the bath has been used up as far as is advisable without risking the permanence of prints. Our opinion is that a method of testing, such as just described, is a better system than allotting so much hypo to fix such-and-such a number of prints or postcards. We think that a system of allowing, say, one pound of hypo for 150 postcards (to quote figures which were recommended a year or two ago by one maker of postcards) is more likely to lead to wastage of hypo than the use of an actual test. Moreover, where large quantities of prints are being put through it is not so readily applied.

(3) *Print Fixer for Plates.*—Inasmuch as almost all development papers can now be fixed in a bath containing four or five ounces of hypo per twenty ounces of water without ill-effect in the way of blisters, it is often possible to pass on the fixing baths (which have done duty for prints) for subsequent use in fixing negatives. But discretion requires to be used. Plainly, it will not do to risk impermanence of negatives for a few ounces of hypo. Plates differ in quite a marked manner as regards the "cleanness" with which they fix out in a bath which is getting near to the "off-strength" point; and it is open to serious doubt whether some plates will fix completely at all if they require to be longer in the fixing bath than, say, fifteen or twenty minutes before the white emulsion disappears. Therefore, in using baths which have been employed for prints an eye should be kept on this point. In any case such baths should be used in tanks, not dishes, in order that a large number of negatives may be fixed together and time thus economized; and further, the fixing bath requires to be kept up to a reasonable working temperature.

(4) *Temperature.*—This brings us to our last point, which is that the fixing-bath, whether for plates or prints, should not be below 60 or 65 degs. in temperature. The temperature should be tested with a thermometer, not guessed, and the bath requires to be kept at this temperature. In the cold dark-rooms which, we fear, in many establishments are the rule, artificial heat is necessary for this purpose. In the case of dishes it is unsafe to warm by placing the dish directly over (even if some distance above) a moderate source of heat, such as a small ring gas-burner turned down to the blue. In such circumstances it is almost inevitable that the fixing solution will not be uniformly heated. If it is left to itself for a while it can easily happen that it will get too warm in places, and may lead to softening or melting of the emulsion coating on prints sufficient to spoil the prints at this stage or to give rise to blistering in the after-process of sulphide toning. Some means should be taken to distribute and equalize the heat. This may be done by standing the fixing-dish in a large baking-tin containing clean sand or fine shot to the depth of about a quarter of an inch, or by placing the fixing-dish in a larger dish containing water. Still more necessary is it to ensure uniform distribution of heat, as far as possible, in the case of fixing tanks, which require to be stood in a larger metal tank—an old washer can often be requisitioned for the purpose—filled with water above the level of the hypo solution in the fixing tank. By taking means such as these, in the case of either dishes or tanks, it requires little ingenuity to adapt any convenient source of heat, such as a ring gas-burner, a small oil stove, or a single paraffin lamp, to keep the fixing solution at a temperature which will make the best of its fixing powers.

There are several other minor measures which should be observed in the economical use of hypo. In making up fixing baths the hypo crystals should be weighed, or measured by bulk. In the days when hypo was the cheapest of commodities it was too commonly the practice to make up baths simply by shovelling the crystals by the handful into the water for their solution.

Another point is that, in transferring prints from the fixing bath to the first wash water a great deal of hypo solution can be carried away and lost. It would probably surprise anyone who cares to make the experiment to find how much fixing bath can be collected from a batch of prints simply by allowing the drippings, which usually find their way to the wash water, to accumulate. If prints are drawn slowly from the fixing bath the greater proportion of the solution will be drawn away from the surface and will be kept in the bath.

But perhaps more important than any of these minor measures is the practice of keeping prints constantly on the move whilst in the fixing bath. Hypo does its work quickly and surely and without waste, but not unless the hypo solution is brought freely into contact with the surfaces of prints and is given the opportunity of penetrating into the pores of the emulsion, whilst at the same time the solution charged with the silver salts from the emulsion can pass out into the surrounding bath. If this essential feature of the fixing process were kept regularly in mind we should hear less of complaints of stains and the like from incomplete fixing.—*British Journal of Photography.*

The Aurora of March 7

The remarkable auroral display on the night of March 7th was so widely visible throughout the United States, and attracted so much attention that the following report by Professor H. C. Wilson, director of the Goodsell Observatory, at Northfield, Minn., which appeared in *Popular Astronomy* will be of interest.

"At Northfield. The display was on when twilight darkened and was still active at 10.45, when our watch upon it ceased. A great green arch extended from the western horizon at azimuth 100° to the eastern horizon at azimuth 280°, passing over the constellation Orion in its course. The arch was wide enough to more than cover Orion. It drifted slowly southward until the lower edge covered Sirius. A narrower arch of the same color occasionally formed and disappeared about midway between the great arch and the southern horizon. Above the great arch was another arch of changeable color, red, yellow and greenish white, composed apparently of nearly vertical streamers, converging by perspective toward a point from 5° to 10° south of the zenith. This arch was very bright red, especially toward the west in azimuth 105°, where it persisted during nearly the whole of the hour from 7.15 to 8.15, after which clouds intervened for a time. During part of the time this arch passed over the Pleiades and Castor and Pollux. Toward the north the auroral display was less brilliant, but there was a low green arch and many comparatively narrow streamers of red and yellowish color converging toward the zenith.

"At nine p.m., when the clouds partially cleared away, the red display had ceased and the green was less active, although it covered a large part of the sky. About 9.35 the red display again became active, but was mostly in the northern half of the sky. The great green arch in the southern sky broke up and almost completely vanished. Later the whole northern half of the sky was filled with streamers, mostly green, converging toward a point 10° south of the zenith.

"A 60° prism spectroscope was turned upon the bright green arch and showed the auroral line as very strong, with four fainter lines almost equidistant from each other, the fourth being near the position of the F hydrogen line. The line at E was invisible or exceedingly faint. When the spectroscope was turned on a very bright red streamer one line could be seen in the red, not far from the *C* line of hydrogen. My impression was that this line was farther than *C* from the aurora line, but I had no means of measurement at hand. At times I thought I glimpsed a line in the yellow also, but I could not be sure of this.

"As such auroral displays are usually associated with extraordinary activity in the sunspots, we took advantage of the next clear day to examine the sun's surface. On March 11, the first opportunity after March 7, a large group of spots was noticed near the central meridian of the sun on the northern hemisphere. The group was approximately 100,000 miles long and the chief spot nearly 20,000 miles in diameter, showing evidences of violent internal motions."

A War Training School

Indianapolis is to have a war training school, the Government having closed a contract for one. The Chamber of Commerce of the city assumes responsibility for training 500 drafted soldiers as gunsmiths, blacksmiths and automobile, airplane and engine mechanics. In addition to the shops at Emmerich Manual Training High School and the Arsenal Technical School, floor space will be obtained in factory buildings.

Filling the mold

Coloring model of apple

Wax Modeling from Nature

A Pleasing Diversion and a Useful Accomplishment for the Naturalist

By Percy Collins

ALL those who have visited the American Museum of Natural History at New York must have been impressed by the triumphs of artistic taxidermy which are there displayed. The stuffed specimens are arranged among life-like reproductions of their natural surroundings, which blend imperceptibly with a painted background. An ingenious illuminating device completes the illusion, and the observer sees before him an actual replica of Pelican sland, Indian River, of a tern nesting place on Cobbs' Island, Virginia, or of some other sequestered haunt of bird life.

Such realistic methods of mounting natural history specimens are now largely adopted by all the important museums of the world. Even small creatures like insects and crustaceans are arranged for public exhibition among reproductions of the objects which commonly surround them in life. It is needless to emphasize the enormous benefit, from an educational standpoint, which results from this practice. But it is worth pointing out that all realistic groups depend for their effectiveness upon the skillful manner in which the vegetation is reproduced. Of course the art of modeling in wax from nature is by no means a new one.

Meadow Crane's bill, a charming English wild flower

An enlarged model of two female flowers of oak tree. The one to the right is represented as bisected to show the inner structure

Finished model of a nettle plant, fully colored

Indeed, some fifty or sixty years ago it was a fashionable pastime with ladies. But between these early achievements and the output of the professional modeler of to-day there is a wide difference. For example, the old-time models of flowers and leaves were composed entirely of wax, the only supports being wires. This gave them a heavy, clumsy appearance quite unlike the real things. Moreover, in process of time the wax hardened, became brittle and was shattered by the least shake or jar; or the sun shone upon the models, with the result that they melted and drooped, being quite incapable of resisting a sudden rise in temperature. On the other hand, the best examples of present-day modeling are not only surprisingly durable, but are calculated to deceive experienced botanists by their surprising fidelity to nature.

The art of scientific modeling has very few exponents. Probably the acknowledged experts of the two continents could be counted upon the fingers of one hand. Special qualifications in the would-be apprentice are indispensable, while the proficients are not unnaturally chary of giving away their secrets. In the following paragraphs, however, the writer is able to describe the processes which are usually adopted; while photographs illustrating various stages of the work are reproduced.

It need hardly be said that in modeling for scientific purposes absolute accuracy in every detail is of prime importance. Nature must be followed implicitly. So the modeler's first care is to obtain an actual specimen of the plant or flower which he desires to reproduce. This specimen is at once placed in water in order that its natural form and freshness may not be lost. A plaster cast of each leaf must now be made. For this purpose the leaves are snipped one by one from the stem and mounted, right side up.

Model of wild rose-blossom, buds and leaves

Carrot bisected to show damage by fly pest

Plaster mold for making model pear, shown below

upon modeling clay—the clay bed being very carefully prepared so that every part of the leaf is evenly supported from beneath, and its natural curves preserved Superfine plaster of paris is then mixed with water to the consistency of thick cream, and a little of this is poured thinly over each leaf. When the first coat of plaster is partially set, another is added, and so on until a fairly thick convex covering above the leaf is obtained. Care must be taken to put on the earlier coats of plaster very thinly, otherwise the natural curves and veining of the leaf may be destroyed by pressure.

When the plaster has set, the leaves are gently peeled away, and accurate impressions of their upper surfaces are found. For convenience in working, the casts are best mounted in somewhat heavy blocks of plaster. Ultimately, when quite dry, the casts should be boiled for a quarter of an hour in a solution of borax, in the proportion of eight ounces of borax to one gallon of water. When cold and dry they will present a smooth, glossy appearance, and be almost as hard as alabaster. By putting the casts into the solution just before it comes to the boil the risk of cracking will be avoided.

The molds are now ready for use; and in practice it is desirable to number each one, and to make a key drawing, so that the position of each leaf on the stem of the plant may not be confused. The actual modeling of leaves is a very interesting operation to witness. Material of two kinds is employed, viz.: sheet wax of the requisite color and thickness, and a kind of waxed fabric. The preparation of the latter is a carefully guarded professional secret; but the material consists essentially of very fine muslin coated on each side with a delicate film of wax. This fabric supports and strengthens the finished leaf and prevents the cold wax from shattering when subjected to sudden vibrations.

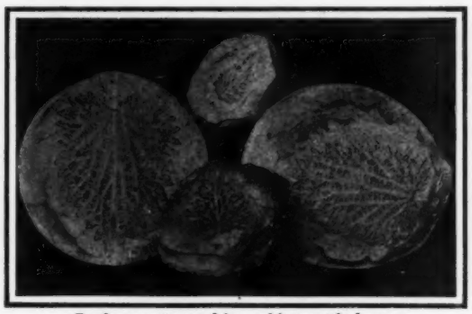
To model a leaf, a plaster cast is first plunged into hot water, taken out, and dabbed with a soft cloth to remove superfluous moisture. Immediately after, a piece of sheet wax is placed above the leaf impression and deftly pressed with the fingers into every vein mark. Next a mid-rib, which consists of a bristle or a wire thinly coated with wax, is placed into position; and over this a sheet of fabric is spread. More heavy kneading of the fingers is now necessary to weld the fabric and wax together, and to bring out the veining

Model of pear blossom

An enormously enlarged model of two male flowers of oak tree

Oak spray with two "marble" galls

The edge of leaf is cut out with fine pointed scissors



Surface casts used in making nettle leaves

in a natural manner on the back of the leaf. When the wax is eventually lifted from the cast a perfect reproduction of the form and venation of the natural leaf is revealed.

All that remains to be done is to trim away with sharp scissors the superfluous wax from the edge of the impression, following each serration very carefully. The edge is then gently rolled upon the palm of the left hand with a glass-headed pin to secure the necessary thinness; wax is added to the wire stem and modeled into the semblance of a petiole; while a few finishing touches reproduce the pose of the natural leaf. In cold weather all these operations must be conducted in a warm room—if necessary close to a fire; otherwise the wax will tend to crack when it is touched.

The process of leaf-making, as described above, seems quite simple and straightforward; yet in practice it entails an enormous amount of skill and patience. No rules can be laid down as to the management of detail. The artist must draw upon his or her own knowledge of botany, and be guided by an innate perception of fitness. Many of the best examples of scientific modeling have been produced by women, whose deft fingers and keen appreciation of color and form seem specially to fit them for the work. It is not enough merely to make up the leaves in the manner indicated. Each must be tinted to the semblance of life, the color of the wax being too uniform in itself. Then the leaves must be fitted together to form a complete plant, every detail of structure being rendered faithfully. As an instance of the care which must be taken in order to secure the best results. We may take the instance of the nettle plant, whose stalk is covered with almost imperceptible hairs, which must be carefully placed, one by one, on the artificial reproduction. These hairs are rendered by means of finely chopped wool fiber which is placed with a camel's hair brush upon the slightly gummed surface of the stem.

The expert modeler is at pains to secure the very finest colors for his work such as will not fade when exposed indefinitely to a strong light. Oil, water and dry colors are all pressed into service, and some of these tints (e. g., rose madder) are exceedingly costly.

For modeling flowers, carefully proportioned cardboard patterns are employed; and the making of these is no easy matter, as each must be an exact ground

Clover: a most tedious bloom to model as each tiny floret must be made separately

Model of pear damaged by wasps, showing in detail how the insects destroy the fruit

plan, so to speak, of a given part of the bloom. No little ingenuity is called into play so that as much as possible of the flower may be cut out in one piece; also that the various parts may ultimately be fitted together without visible joins. This remark applies especially to asymmetrical and tubular blossoms; and every modeler has his or her own methods.

By means of the patterns the parts of the flower are cut out in fabric, or in fabric faced with sheet wax, and these parts are gently rolled and pressed with a modeling pin into their natural shape. The flower is then put together, the stamens being imitated by waxed silk or finely snipped fabric. Flowers are generally modeled in white or very pale wax into which dry powdered colors are subsequently rubbed by means of artists' stumps, and made to blend in imitation of nature. A skilled worker will thus reproduce the most delicate tints and the finest details of adornment. Some of the most effective flowers, such as the wild rose or the meadow crane's bill, are comparatively easy to model; others demand an enormous amount of detailed labor. The various kinds of clover, for example, are among the most tedious blooms to reproduce. Each little floret must be made up separately, and fitted together—a hundred or more of them for each bloom—among the minute green sepals of their tiny calyces. Naturally such work as this is costly, and the floral embellishments of a museum may represent an expenditure of many hundreds of dollars.

Many little "tricks of the trade" enhance the appearance of the finished model. We have already seen that minute hairs are imitated by chopped fiber. Arrowroot, when rubbed into the surface of wax, produces a delicate bloom. Powdered asbestos, similarly applied, gives a glossy effect such as we see upon the petals of many kinds of flowers, while a high polish is imparted by varnishing the wax with gum sandarach dissolved in alcohol.

Such objects as fruits and vegetables are cast in plaster of paris molds, the latter being made in two or more pieces as may be required. This mold is first soaked in cold water. A quantity of molten wax is then poured into one of the cavities, the pieces of the mold are rapidly fitted together, and the whole is then rotated in the hands until the wax sets. In this way a light and hollow cast is secured which is subsequently colored from a natural copy. The stalk and calyx, or any other necessary additions, are modeled separately and then fixed to the cast. Many life-like models of fruit and vegetables may be seen in our museums. They are commonly used to illustrate various phases of botanical study, especially in cases where natural specimens cannot be satisfactorily preserved. Recently this wonderful art has been pressed into the service of agriculture. Models are made to illustrate the damage done by insects and other pests; so that the farmer can see at a glance what is causing his loss, and take steps to apply the remedies which science suggests.

Sometimes models of natural objects on a greatly enlarged scale are in demand for educational purposes. We may take as an example the flowers of the oak tree—male or pollen-bearing flowers, and female or fructifying flowers. Both are exceedingly small, but the models shown in the accompanying photographs represent them as they appear when highly magnified. In such a case the various parts must be first modeled in clay—the correct proportions being gaged by means of scale drawings worked out with the aid of the microscope. From these clay patterns molds are made in plaster and in these the units of the permanent model are cast in wax. The several parts are then fitted together and colored.

Unsinkable Ships—II*

Previous Systems Discussed and a New Method Suggested

By Charles V. A. Eley

[Concluded from Scientific American Supplement No. 2206, Page 239, April 13, 1918]

Many problems presented themselves to me, the most important being:

1. What description of pump would best fulfil the purpose required, having regard to efficiency, space necessary, weight and ease of installation?

2. Would it be advisable to sacrifice efficiency to obtain decrease of weight and space required?

3. Would it be wise to sacrifice efficiency so as to be able to eliminate the possibility of not being able to operate the pumps owing to breakdown of the main engines?

4. Or would it be best to hold on to efficiency, combined with an increase of weight, and have the pumps quite independent of the main engines, even at the sacrifice of weight in other matters connected with the ship; or even if it meant carrying a little less fuel, especially as the means of coaling vessels at sea or getting oil fuel aboard have improved greatly during the past few years.

5. How should the water dealt with be passed out of the ship?

I will endeavor to deal with each of the problems in my own way; not that I expect to lay down any hard and fast rule thereby, because the problems will be sure to crop up again at the time of application, and varying conditions will call for different decisions in specific cases.

Dealing now with these problems in bulk, I consider that the best kind of pump to use for the work would be involute centrifugal single stage pumps; but in certain cases the Expulsor form of steam pump, or even steam jet pumps might be considered, as an installation of the latter would be better than no installation at all. In round figures, the comparative pumping capacities of these pumps would be about as follows, in gallons pumped per pound weight of steam available:

Centrifugal pumps, 168 gallons per lb. of steam against a 40 ft. head.

Pulsometer pumps, 15 gallons per lb. of steam against a 40 ft. head.

Steam jet pumps, 4 gallons per lb. of steam against a 40 ft. head.

This would mean in a vessel like the *Olympic*, whose boilers are capable of evaporating, I should say, about 750,000 lbs. of steam per hour, the possibility of doing the following duty:

Centrifugal pumps .....126,360,000 gal. per hour
Pulsometer pumps ..... 11,250,000 gal. per hour
Steam jet pumps..... 3,000,000 gal. per hour
respectively.

The numbers and weights would work out roughly as follows with ordinary commercial pumps:

234 20-in. centrifugal pumps, weighing 600 tons, pumps only.

150 9-in. Pulsometer pumps, weighing 375 tons, pumps only.

300 3-in. steam jet pumps, weighing 10 tons, pumps only.

And the price about as follows:

234 20-in. centrifugal pumps, £35,000, pumps only.

150 9-in. Pulsometer pumps, £20,250, pumps only.

300 3-in. steam jet pumps, £1,500, pumps only.

The weights and prices of the centrifugal pumps and the pulsometers could be, however, considerably reduced by making the bulkhead plates form one side of specially constructed pumps, probably to two-thirds of the weights and amounts stated above. Other special constructions which I have in mind might reduce the weight even still further. To the weights and costs given must be added extras for any pipes and valves required, fixing, and for the starting arrangements.

It will be noticed that the steam jet pumps show up the best for weight and cost. They would also be the easiest to instal, but they would only be capable of getting rid of one-fortieth of the quantity of water that the centrifugal pumps would. The Pulsometer pumps appear to be the most costly, and the heaviest of the three arrangements in proportion to the work they could do, but they have the same advantage as the jet pumps, inasmuch as they can be operated directly by the steam instead of requiring some intermediate power as the centrifugal pumps do, such as driving by separate engines, or off the propeller shafts or counter-shafts. The pulsometers are also capable of greater deeds than the steam jet pumps, as they could pump over 11,000,000 gallons per hour instead of 3,000,000 gallons.

The question therefore arises: Would a ship like the *Olympic* ever be damaged to a greater extent than to require pumping arrangements to deal with more than 3,000,000 gallons per hour beyond the quantity it would be possible to pump with her auxiliary pumps?

Let us suppose that such a vessel has been damaged about 25 feet below the water line by a submerged rock or an iceberg, and that the captain and engineer have agreed to let her keep a level keel until they see exactly what the damage amounts to. Therefore, they let the water flow level in the ship so that it will reach the suctions of ballast pumps and the centrifugal pumps. For present purposes we will assume that such pumps would be capable of the following duties:

5 ballast pumps	1,250 tons per hour
3 bilge pumps	450 tons per hour
4 centrifugal pumps	16,456 tons per hour
Tons per hour.....	18,156

And the proposed steam jet salvage pumps 13,392 tons.

We get a total of 31,548 tons per hour, which would deal with all of the incoming water entering the ship through a hole 4 ft. by 2 ft. at 25 ft. below the surface of the water. If the maximum damage is likely to be greater than this, then the expulsor form of pump could be considered, in which case we would have:

Capacity of auxiliary pumps per hour.....	18,156 tons
Capacity of pulsometer pump per hour.....	50,224 tons
Total	68,380 tons

This total of 68,380 tons per hour would be equal to the incoming water entering the ship through a hole about 6 ft. by 3 ft. at 25 ft. below the surface of the sea, provided the ship was permitted to keep a level keel.

If a still greater margin of safety is desired, it could be obtained by either an arrangement of centrifugal pumps driven by separate engines, or by means of clutches or change wheels, putting the propellers out of gear and countershaft in gear, to drive centrifugal pumps by the main engines. Taking the separately driven pumps first, there would be sufficient steam to drive about 234 20-in. pumps capable of delivering about 564,107 tons per hour. Adding the capacity of the auxiliary pumps, we get a total of 582,263 tons per hour, which total would deal with the incoming water through a hole about 15 ft. by 10 ft. at 25 ft. below the surface of the sea; a much larger hole than I believe would be made by a mine or torpedo.

If special light bulkhead centrifugal pumps were used, driven off the main engines, weights would be reduced, whilst the efficiency of the plant would be at its best. The only drawback would be, if the engines were broken down the pumps could not be worked. It is not likely, however, that all three engines would be placed *hors-de-combat* at the same time. In this case, if the engines were capable of working at 55,000 h.p., as many as 390 20-in. centrifugal pumps could be operated, giving about 936,000 tons per hour, or with adding the capacities of the auxiliary pumps about 954,156 tons per hour, which would deal with the incoming water through a hole 24 ft. by 10 ft. at 25 ft. below the surface of the sea; or a hole 150 ft. by 5 ft. at the surface of the water, the latter measurement being taken from the water line to 5 ft. below it. It will be seen, therefore, that there is no limit to what could be done in the way of pumping water out of such a ship right up to the huge cavities mentioned, which are very unlikely to occur even though the vessel received torpedo damage or is riddled with shot-holes.

Assuming that such vessel has a length of 852 ft., a mean breadth or beam of 72 ft. above water, and a freeboard of, say, 35 ft., we would have a maximum capacity of 2,147,040 cubic ft.; or 61,344 tons of water would be required to sink the ship on an even keel. As such a state of things would mean that the vessel would sink in about 3 minutes 56 seconds if no pumps were working, we can immediately say it is unnecessary to make such extreme provision. If provision is made against such a vessel sinking at, say, 20 or 30 minutes rate, I think it would be all ever needed, no matter what the kind of accident, provided that her double bottom was extended up to the sides to, say, 5 ft. above the water line.

As I estimate that the amount of damage received by the *Titanic* could not have amounted to more than six square feet of perforation at about 25 ft. below the surface, it would appear to be quite unnecessary to provide for the before mentioned 25 by 24 ft. by 10 ft.=

*An abstract of a paper read before the British Institute of Marine Engineers. From a report in *The Steamship*.

240 square feet, or 40 times the amount of damage received by the *Titanic*. I would, therefore, suggest that in a similar ship the following pumping provision should be made:

1. That the bilge suctions on the centrifugal circulating pumps be 30 in. diameter.

2. Four centrifugal pumps with 50 in. suctions and delivery inlets and outlets arranged to be driven by the four sets of electric light and power engines, each of which, say, are capable of developing 550 B.H.P. These four pumps would be capable of delivering about 650 tons of water out of the ship per minute, making the capacity of the auxiliary pumps up to 1,000 tons a minute. (The emergency electric light engines could be brought into operation whilst the larger ones were employed on pumping duty).

3. On or near the five aftermost bulkheads I would suggest the fixing of sixty 20 in. centrifugal pumps, to be operated directly from the main engine and turbine shafts, and so arranged as to be driven by chain or toothed gears, whichever is found most suitable for the positions in which it is best for the pumps to be placed.

These sixty pumps would deliver about 2,500 tons of water per minute, making the total capacity with the auxiliary pumps about 3,500 tons per minute. The same sixty pumps would absorb about 10,000 B.H.P. of the 55,000 B.H.P. of the main engines and turbine.

4. If it could be arranged, I would also suggest running two very large suction mains right forward and aft to the second bulkhead from either end of the ship. I would also suggest the fitting of large valves or sluice gates on such second bulkheads, and others at each compartment and on the forward and aftermost bulkheads.

5. The necessary delivery pipes and valves to complete the installation.

I estimate the foregoing would cost:

Additions to auxiliary plant, including four 50-in. pumps	£2,000
Sixty 20-in. centrifugals	10,000
Wrought-iron pipes, valves and fixing	3,000
	£15,000

This expenditure would ensure that in event of the ship meeting with disaster of the worst kind, the machinery would be capable of getting rid of 3,500 tons of water per minute, and at the same time making for port under her own steam at about three-quarter's speed. The extra immersion due to the extra weight would be nearly two inches only. These additions would provide a 17½ minutes' sinking rate.

As my estimate of the damage to the *Titanic* represents the water pouring into the ship during the first ten minutes amounted to 318 tons per minute, it is safe to say that the foregoing arrangements would deal with eleven times the amount of damage which happened to the *Titanic*, without having to close a single water-tight door or destroying the "trim" of the vessel. Further, if the ship is very badly damaged in any two of her water-tight compartments (other than those containing the engines) such compartments could be isolated if deemed necessary, and other compartments flooded, if thought desirable, to keep an even keel. For example, suppose her two forward compartments are badly damaged by a head-on collision with which the pumps could not cope. The water-tight doors, if any, could be closed, and by means of one of the large proposed suction pipes the two aftermost compartments could also be flooded and the vessel kept on a level keel, whilst the pumps could be made to deal with any other incoming water. Again, there is another and a very important factor. When it is found that the pumps are mastering the water as it enters the ship, many a clever engineer or ship's carpenter would quickly devise means of using material on board to reduce the inflow of water to a minimum.

In event of the foregoing scheme appearing too ambitious, the owners of such a vessel would perhaps be prepared to adopt a more modified one by fitting into the vessel, say, 300 3-in. steam jet pumps 75 6-in. ones. Either would deal with about 220 tons of water per minute, and would cost only £1,500, or, say, with pipes and valves and fixing, £2,000. Add to this the suggested cost of the alterations to auxiliaries, £2,000, it would only cost £4,000 to bring the machinery up to a point to drive out incoming water at the rate of 1,220 tons a minute, a rate four times greater than the water entered the *Titanic*. But, as the whole of the steam used by the main engines would be required to operate the steam jet pumps, the vessel would have to "heave to" until the holes had been stopped. This would be bad for the vessel if submarines were about, or even in a storm.

Another scheme, not so costly as the first, and not quite so moderate as the second, might, therefore, find favor. That is, to instal two more 50-inch centrifugal pumps with steam engines of 550 b.h.p. each complete. These would cost about £2,000, or, with pipes, valves, and fixing, say £3,000. Again, adding the £2,000 for additions to auxiliary pumps, we arrive at a total expenditure of £5,000, and there would be sufficient pumps on board to deal with 1,320 tons of incoming water per minute, which is over four times the rate that the water flowed into the *Titanic*, but would only be sufficient to cope with a 46-minutes' sinking rate. At the same time, the vessel could continue her journey, as there would be sufficient steam left for the vessel to travel at 21 knots per hour. It might even be that the speed of the vessel would be increased, if by an ingenious arrangement of the valves and pipes on the delivery side of the pumps the streams of the outgoing water could be directed right astern below the water-line. The extra immersion of the ship due to the added weight of the six 50-in. pumps and two sets of engines and necessary pipes and valves could be ignored in a vessel of such a large size, as the weight would amount to only about 100 tons, giving an extra immersion of the ship of only half an inch.

To sum up, I think that the owners and engineers of any vessel engaged in passenger service should not neglect this engineering side of a ship's life-saving apparatus, for the *Titanic* might never have sunk had she have had the above-proposed £5,000, or even much less, spent upon her; in fact, there would have been no need probably for the officers of the ship to let the passengers know even that any danger existed, as the speed of the ship need not have been reduced materially except as a caution against meeting more ice, and no water-tight door need have been closed.

The saving of a ship from sinking is an engineering matter absolutely, consequently such work should come under the direct control of the chief engineer of the vessel; and the engineer in charge during a "watch" should be fully qualified to act just as his chief would do in cases of emergency. The marine engineer should train himself fully in the subject of "How to save a sinking ship." He should arrange, if possible, a full set of indicators at some central point to show at a glance the height of water in any compartment. This will enable him to act with promptitude in times of great danger. He should see that all the necessary appliances for restricting and stopping the flow of water into a ship are kept in some place or places in the ship in the same manner as is done with apparatus for fire service. He should also make himself thoroughly acquainted with the pump connections in the ship, and see that every possible pump is arranged to pump out the bilge to the sea. If any pumps are not so arranged, it should be his duty to at once inform the responsible individual in writing, pointing out the necessity of such an arrangement. It may seem to some not necessary to point out such matters as these, but one cannot take too great precautions. The marine engineer should, therefore, make this question of salvage pumps one of his special hobbies. It may at some time or other be the means of saving many lives besides his own. He should also make himself master of the water-tight bulkhead and the water-tight deck questions, and try to arrange problems as to what would be likely to happen if his vessel was perforated at certain points, either through running head-on to rocks, or scraping rocks or icebergs, or by collision, by projectiles or torpedoes, or in any way which may suggest itself to him. He would then be more ready to act in cases of great emergency, and not be so likely to do the wrong thing, as he would probably do if he did not make a study of such matters.

Let us now see how he would be expected to act in order to prevent the sea entering the vessel. Then we will see at the same time what is likely to be required in the way of material to be used for stopping leaks. Let us take cases of collision first. Suppose his vessel has just been run into by another, and the other vessel has backed out instead of keeping her bows in the breach made until the crew have got a collision mat ready to place over the hole. The water would be pouring into the ship chiefly through the upper side of the vessel. The salvage pumps would be started, the valves on the circulating pumps could be closed to sea suction and opened to bilge suction, and all boiler-feed pumps could be set to pump from the bilge if necessary, if they had been arranged for such duty.

Whilst this work was going on in the engine and boiler rooms, the ship's carpenter should at once prepare on the weather deck a collision mat of strong materials, say 3-in. planks with sufficient channel iron or plates fastened thereto on the outer side to sink the mat and give it necessary strength, and an old sail or rubber sheeting nailed on the inner side of the mat. Whilst the mat is being made an old sail could be suspended over the hole, a couple of iron bars being pushed through it so as to prevent it being drawn into the ship. Members of the crew could be preparing the ropes to suspend the mat, to guide it into position, and to keep it in its position after it is placed.

There will be plenty of scope for the engineer to use any material he may have at hand, also according to the exigencies of the occasion. For instance, with internal planking he could nail rubber or insertion strips on one edge of each plank, and when all the planks were in position, by wedging down from the top, he could prevent the water entering at the joints. Or, if he considered it necessary, either for strength or greater protection, he could plate the outside of each plank with iron or steel. Again, if he had an iron plate on board large enough, and there was sufficient headroom to enter the plate into slots, he could put such plate into position instead of the planks, afterwards making it tight round the edges by wedging the plate close to the side, driving in packing where necessary. By any of the foregoing methods the engineer could make a good temporary patch, which would last until the vessel reached a port where proper repairs could be carried out; therefore, he should carry materials on board, and keep them handy so that he could make a patch at short notice. If his vessel is arranged with water-tight doors, and water-tight scuttles in the decks, they will require very careful manipulation. If it is found that the pumps can deal with all the incoming water, no doors should be closed. If it is found that the water is gaining on the pumps, even to a small extent, all doors should be left open, as in a short time the inrush of water would be restricted, and then the pumps would gain on the water. If the indicators show that the water is rising rapidly in any compartment, and that the pumps are not capable of dealing with the situation, then the compartment must be isolated:—

1. If the orlop deck is a water-tight one with water-tight scuttles, and the damage is below such deck, the water-tight scuttles in the same should be closed.

But if the damage is above such deck, the water-tight scuttles in same should not be closed. If they are closed the water will build up on top of such deck and probably destroy the stability of the vessel, and cause it to "turn turtle." Only the scuttles in the decks above the damage should be closed.

2. All water-tight doors on the bulkheads of the compartment to be isolated should be closed. Then, if the damage is below the orlop deck, and the orlop deck is a water-tight one, a very small quantity of water will be locked up.

Double Compounds of the Metallic Halides with Ether

THE double compounds of the metallic halides with ether hitherto known are those with glucinum and titanium chlorides and with aluminium, mercuric and stannous bromides. The *Journal of the Chemical Society* for September contains a description by Messrs. A. Forster, C. Cooper, and G. Varrow of the preparation of double compounds of ferric chloride with ether and with benzyl sulphide. The former compound, $C_4H_{10}O$, $FeCl_3$, obtained by the interaction of anhydrous ferric chloride and dry ether, is a dark red, highly deliquescent solid soluble in benzene, but decomposed by alcohol or water. When heated it evolves pure ethyl chloride. The substance in ethereal solution reacts with dry ammonia, giving brick-red, amorphous compounds of varying composition. Benzyl sulphide ferric chloride $(C_7H_7)_2S,FeCl_3$, obtained by mixing ethereal solutions of its two components in molecular proportions and allowing to stand for some hours, forms minute lemon-yellow crystals soluble in chloroform and slightly so in alcohol, but insoluble in ether or acetone. The crystals rapidly become brown on exposure to moist air, this reaction distinguishing them from tribenzylsulphinium chloride ferrichloride. Benzyl sulphide ferric chloride is slowly decomposed into its two constituents by water; with alkalis the products are benzyl sulphide and ferric hydroxide. If a solution of equimolecular proportions of benzyl sulphide and cyanide in dry ether is added to an ethereal solution of ferric chloride, tribenzylsulphinium cyanide ferrichloride, $(C_7H_7)_2SCN,FeCl_3$, is formed. This substance is obtained as lemon-yellow crystals insoluble in ether, but soluble in alcohol and chloroform. When treated with excess of ammonia in alcoholic solution the substance gives tribenzylsulphinium cyanide, $(C_7H_7)_2SCN$, which forms large white prisms, m.p. 41 degrees, readily soluble in organic solvents, but only slightly so in water. In contact with water the cyanide completely dissociates in a few hours.—*Nature*.

From The Engineer

A four-cylinder express passenger locomotive on the Great Central Railway in England

A Typical British Locomotive

BRITISH railway practice differs from that in the United States in many respects, particularly in the matter of locomotive design. From our point of view it would appear that the British engineers are fond of experimenting, for among a multitude of types to be found on their roads, especially among their passenger locomotives, there are many that strike us as extremely novel, as for example engines having three cylinders, compounded, and original arrangements of four cylinders, both simple and compound. An interesting specimen of the four-cylinder type was recently described in *The Engineer*, London, as follows:

"The first engine of a new class of heavy high-speed mixed traffic locomotives was completed towards the end of the year at the Gorton Works, and is now in regular service on the Great Central Railway. It is of the 4—6—0 type, and has four high-pressure cylinders, each 16 in. diameter with a stroke of 26 in. The four cylinders are placed in line above the bogie, the inside pair being cast in one, with a common steam chest.

The piston valves are all 8 in. diameter and are placed above the cylinders. They are fitted with pressure release rings, which act both as priming and drifting valves. The inside cylinders have inside steam admission, while the outside cylinders have outside admission. As adjacent inside and outside cranks are at 180 deg. with each other, and their pistons are always moving in opposite directions, the valves of each pair of inside and outside cylinders synchronize in their movements. They are, therefore, driven by the two parallel upper arms of a three-armed rocking shaft, the lower arm of which falls between the frames and is driven from the leading coupled axle by a set of ordinary link motion.

In order to eliminate the high driving axles stresses that inevitably accompany high tractive power, whether developed by inside or outside cylinders, or by four cylinders driving one axle, the engine is designed to divide its power equally between the first two coupled axles. Thus the inside cylinders drive the leading coupled wheels through a crank axle, and the outside cylinders drive the next pair by pins in the wheel centers.

The length of the outside connecting-rods would, under this arrangement, be exceptionally long, and to keep it within reasonable limits the outside piston rods are lengthened and pass through steadying bushes in the slide-bar brackets. The slide-bar brackets themselves are of cast steel and of unusual design, and are solely responsible for the support of the outside slide-bars which are not attached to the hind cylinder covers. The attachment of these brackets to the frame occurs at the same place as that of the inside motion plate, and from that point the casting extends back as two cantilevers carrying the upper and lower slide bars outside the leading coupled wheel.

The valve spindles are supported by substantial guides cast in one with the steam chest covers, and there are no obstructions whatever in the shape of rocking levers or other attachments to interfere with removal of any of the front cylinder or steam chest covers, or withdrawal of any of the pistons or valves.

Laminated underhung springs with all the links in tension are used for all the coupled wheels.

The bogie is of the Great Central Railway Company's standard design, having cross travel of 6½ in.—controlled by an elliptic check spring—which is sufficient to enable the engine readily to pass over curves of 5 chains radius.

The boiler is a duplicate of that used for the 4—6—0 two-cylinder engines of the "Sir Sam Fay" and "Glenalmond" classes. The barrel is telescopic, 17 ft. 3 in. long, made of three ⅝ in. plates, the outside diameter of the largest ring being 5 ft. 6 in. The fire-box casing is of the flat topped type, 8 ft. 6 in. long outside. This class of boiler was originally fitted with a "Robinson" superheater of twenty-four elements, but the number of elements has lately been increased to twenty-eight, both for new engines and renewal boilers, in order to raise the working temperature of the steam from about 600 deg. to 650 deg. Fah. The elements themselves are of the short return loop type, the tubes containing them being 5¼ in. outside diameter. There are 116 small tubes, 2¼ in. outside diameter. The heating surface of the elements, which are 1⅝ in. outside diameter and 1⅛ in. bore, is 343 square feet, and of the tubes 1,881 square feet outside, the fire-box having 159 square feet, making 2,383 square feet in all. The grate area is 26 square feet, and the working pressure is 180 lb. per square inch.

The superheater header is of cast iron, with mild steel front covers. It is provided with four steam branches, two above the covers and two below, near the smoke-box sides. The former branches supply the two outside steam chests, the latter the inside. All steam-pipes, both in the boiler and smoke-box, are of solid drawn mild steel. Neither dampers nor draught retarders are fitted, but an anti-priming steam circulator worked by the blower valve is provided, and also a header discharge which is operated by a positive gearing connected with the regulator handle, and exhausts the contents of the header and elements into the blast pipe, when the regulator is closed. Reversing is effected by means of a screw gear on the right-hand trailing splasher, placed well forward and partly outside the cab, so that the driver can stand behind the screw and have ready access to all the fittings and an uninterrupted view ahead.

Two 10 mm. restarting injectors are fitted below the footplate, and the engine is provided with a steam brake with blocks on all the coupled wheels, controlled by an automatic valve in connection with the vacuum ejector, which is of the "Dreadnought" type.

Lubrication for all four steam chests and cylinders, as well as for the four driving axle-boxes, is effected by a forced sight-feed "Intensifore" lubricator in the cab. In this lubricator there is one intensified cylinder feeding oil at 270 lb. per square inch to two distributors, one on each side of the cab. Each distributor has six sight feeds, two of which supply the driving axle-boxes, and four the steam chests and cylinders on the corresponding sides of the engine.

The tender is of the Great Central Railway Company's standard pattern, carried on six wheels. It has a water capacity of 4,000 gallons, and carries 6 tons of coal. It is fitted with a water pick-up apparatus, and has an automatic steam brake cylinder actuating blocks on all wheels, as well as a screw hand brake.

The total weight of the engine in working order is 77 tons 18 cwt., of which 20 tons 15 cwt. fall on the bogie wheels, 19 tons 10 cwt. on each pair of driving wheels, and 18 tons 3 cwt. on the trailing coupled wheels. The weight of the tender fully loaded is 47 tons 6 cwt.

Owing to the large amount of lateral play given to the bogie, the engine buffers have been given elliptical heads, and a large amount of lateral radiating movement is given to the leading drawbar. For the same reason the platform width is reduced forward of the leading coupled wheels, so that the engine can readily clear the structure gauge on curves of any railway.

This handsome locomotive is intended for heavy fast passenger, goods, fish or mail traffic, over a line having a ruling gradient varying from 1 in 176 to 1 in 100 at speeds necessitating an output of up to 1,600 indicated horsepower with full loads. We may mention that it is fitted with the "Reliostop" automatic train stop and control apparatus, similar to that used on many other engines of the Great Central Railway.

Coal Used by Locomotives

UNTIL recently nearly all coal used on locomotives was mine-run—the entire unscreened product of the mines. In the past few years, however, increasing quantities of screened lump coal have been used in locomotive service. This increase in the consumption of lump coal has been due partly to the belief that lump coal, when burned on a locomotive, produces enough more steam than mine-run coal to compensate for its greater cost. Special considerations, such as the desire to lessen the amount of smoke formed, have also led in some instances to the use of lump coal, which is generally believed to require less skill in firing than mine-run coal. The introduction of the mechanical stokers for locomotives has resulted in the use of increasing amounts of various sizes of screenings. Thus far there has been little use of such sizes as egg, egg-run, and nut coal on locomotives, although traffic and market conditions occasionally make it feasible and desirable to use them.

The relative values of several sizes of coal for locomotive use have not been well understood, since most laboratory and road tests have been made with mine-run or occasionally with lump coal, and the data are inadequate and conflicting.

A series of tests to determine the value of different sizes of coal has been conducted by the Engineering Experiment Station of the University of Illinois under a co-operative agreement with the International Railway Fuel Association and the U. S. Bureau of Mines. A Mikado locomotive weighing 142 tons belonging to the B. & O. R. R. was used, the tests being made in the locomotive laboratory at Urbana. The results are published in bulletin No. 101 entitled "Comparative Tests of Six Sizes of Illinois Coal on a Mikado Locomotive," by E. C. Schmidt, J. M. Snodgrass, and O. S. Beyer, Jr.

Preserving Perishable Food Stuffs

THE London *Times* recently gave an account of an improvement by Dr. S. A. Kapadia in the Lawton method of preserving perishable foodstuffs. In that system the produce was kept under anaerobic conditions, so that putrefactive and other changes were arrested, but the objection to it was that the gas used contained carbon monoxide, forming an explosive misture in the preserving chamber. The gas used by Dr. Kapadia consists of nitrogen and carbon dioxide, with only a trace of oxygen. Australian apples which had been kept for five weeks in this atmosphere were found to be in as good condition as at first, and the rottenness from some of the specimens had not spread to the neighboring sound fruit. Raspberries, a fruit very difficult to preserve fresh, after a fortnight of the same treatment were as fresh as when the experiment started, and, moreover, they retained this freshness for four days after removal from the preserving chamber, thus allowing time for the fruit to be marketed. After salted fish had been kept in the preserving chamber for six weeks it appeared to an expert to be in exactly the same condition as when introduced. Similarly, eggs which had been preserved for 20 weeks in the same way could be afterwards boiled without the shell cracking, as if new-laid.—*Nature*.

The Study of Indian Music*

Recent Developments Through a New System of Analysis

By Frances Densmore, Bnreau of American Ethnology

THE development of many sciences is dependent, to some extent, on the development of the instruments used in making their observations. On the accuracy of these instruments depends the accuracy of the science, though mechanical means are aided by the experience and intelligence of the observer.

The first method of studying Indian songs consisted in writing them down by ear. Indian songs were thus preserved by Miss Alice C. Fletcher, Dr. Hoffman, Dr. Boas and Mr. Mooney, while Dr. Stumpf and Dr. Theodor Baker represented the foreign investigators in the field. But the invention of the phonographic recording apparatus marked an epoch in the work. It then became possible to hear a song over and over, and to compare renditions of a song by several singers. Miss Fletcher at once availed herself of this aid and used the phonograph in recording Indian songs during the latter part of the eighties, and Dr. Fewkes demonstrated its use on Indian songs at a meeting of the National Academy of Sciences at Boston, in 1891. Since that time a very large number of Indian songs have been recorded on the phonograph, and it has become customary for ethnologists to make phonographic records of the songs occurring in the myths or ceremonies under study. This preserves the songs for future examination and has become an important phase of the study of Indian music.

Since the introduction of the phonograph its mechanism has been steadily improved, but the transcription of the songs must still be done by ear. Looking forward to the further development of this study, it seems probable that the next epoch-marking invention will be that of a device for transcribing the songs. Such a device would eliminate the personal equation and show us mechanically the number of vibrations in each tone produced by the Indian; it would prove or disprove much that is now a matter of speculation and might justify the use of special notation, or a minutely graded scale, for the graphic representation of Indian singing. For several years this problem has received the attention of students, and it seems to be approaching solution.

The work of the writer consists in the recording, transcription and analysis of Indian songs, five tribes having already been studied. The method of the work is as follows: A phonograph is taken to the Indian reservation and songs are there recorded by the Indians. The next step is the transcription of the songs in ordinary musical notation, the pitch of each tone being indicated as nearly as possible on the lines and spaces of the musical staff. The only special signs used are a plus or a minus sign, placed above a note to indicate a considerable deviation from pitch.

Having recorded and transcribed the songs, the next step in the work consists in their analysis by a system that the writer has developed during the recording and observation of about one thousand songs. This system of analysis reveals many peculiarities of the songs, but only three will be considered here. The first peculiarity to be shown is melodic in character and suggests a feeling for a fundamental tone and its principal overtones. In demonstrating this we will proceed from the familiar to the unfamiliar and briefly note the structure of the musical system of the white race, with which we are to compare the music of the Indian. The group of Indian songs to be used in this comparison comprises six hundred songs collected among the Chippewa and Sioux.

In the musical system of the white race the principal intervals are the octave and the dominant. These intervals are not arbitrary, but had their rise in the laws of acoustics. The overtones of a fundamental were demonstrated a generation ago, and the first three overtones are the octave, twelfth, and fifth; the twelfth being the dominant in the upper, and the fifth in the lower, octave. The work of comparison was as follows:

*Extract from Proceedings of the Nineteenth International Congress of Americanists, Washington.

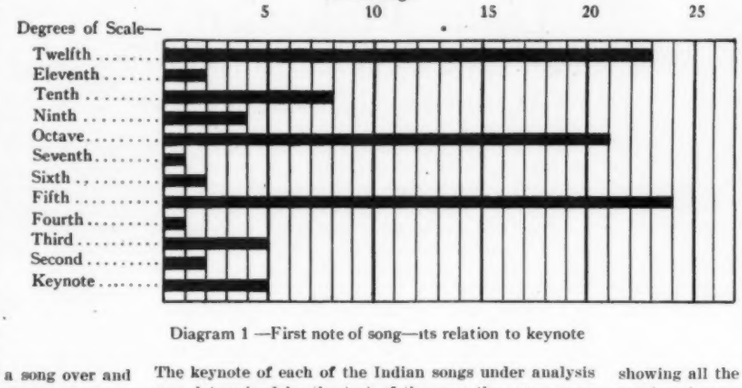


Diagram 1 —First note of song—its relation to keynote

The keynote of each of the Indian songs under analysis was determined by the test of the ear; the songs were then examined to determine the relation of the first tone to the keynote (tonic). It was found that 21 per cent. begin on the octave, 23 per cent. on the twelfth, and 24 per cent. on the fifth, the latter class comprising songs having a compass of fewer than twelve tones. It was further ascertained that 5 per cent. of the songs begin on the keynote; thus 73 per cent. of the six hundred songs begin on the keynote and its first three overtones. Next in importance to the octave and dominant may be placed the third of the scale, and it is interesting to note that 13 per cent. of the songs begin on this interval, which is called the *tenth* in songs having a compass of ten tones above the keynote, and the *third* in songs of smaller compass. These percentages, as well as those of songs beginning on other intervals, are shown in the accompanying diagram 1.

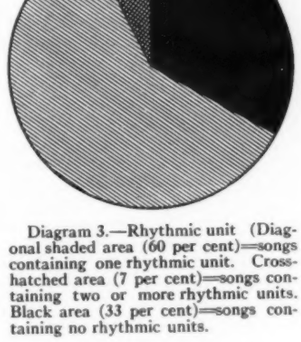


Diagram 3.—Rhythmic unit (Diagonal shaded area (60 per cent)=songs containing one rhythmic unit. Cross-hatched area (7 per cent)=songs containing two or more rhythmic units. Black area (33 per cent)=songs containing no rhythmic units.

On examining these songs to determine the final tone, it is noted that 61 per cent. of the songs end on the keynote. It is further noted that 25 per cent. have a compass of twelve tones, beginning on the dominant in the upper octave and ending on the keynote. These melodic peculiarities suggest a feeling for the keynote and its three principal overtones.

The second melodic peculiarity to be considered is the prominence of the minor third. It is a familiar saying that "Indian music is in minor keys," or that "Indian music has a weird, minor sound." This is a popular impression, and as it is held by many people we may be permitted to use it as a starting point, and to make a careful examination of our group of six hundred songs in order to determine whether the impression is founded on fact.

After deciding on the keynotes of the several songs, the writer divided them into groups of major and minor tonality according to the interval between the keynote and the third. As a result of this test it was found that 50 per cent. of the songs were major in tonality or, to use the common musical terminology, were in major keys. This shows that the popular impression was not due to the "keys" of the songs. A table was then prepared showing all the intervals occurring in the songs. These numbered more than 16,000, and the minor third constituted 30 per cent. of the entire number; indeed it was the most frequent interval, except the major second, which was often used as a passing tone, having slight melodic importance.

The frequency of occurrence of the principal intervals in these songs is shown in diagram 2, the minor second comprising 3 per cent., the major second 41 per cent., the minor third 30 per cent., the major third 10 per cent., and larger intervals 16 per cent. of the number of progressions.

Continuing this analysis, the entire number of intervals was expressed in terms of a semi-tone by multiplying the number of occurrences of each interval by the number of semi-tones it contains and combining the result. From this total (48,805 semi-tones) the average interval was computed and found to contain 3.02 semi-tones. As a minor third contains three semi-tones, it is seen that the average interval in these songs is approximately that interval. From these observations it appears probable that the "minor sound" of Indian songs is due to the prominence of the interval of a minor third.

We will now proceed to a third peculiarity of Indian music as shown by the analysis of six hundred Chippewa and Sioux songs. This peculiarity is rhythmic, and consists of a short unit of rhythm, repetitions of which occur in the song; these repetitions, frequently interspersed with other phrases, give a rhythmic completeness to the melody. Sixty per cent. of the songs under analysis contain one rhythmic unit, and from two to five rhythmic units occur in slightly more than 7 per cent. of the songs. In many instances the rhythmic divisions of the first unit are reversed in the second, and in songs containing two or more rhythmic units there is usually a similarity between all or a portion of them, though each retains its own individuality and is accurately sung. Diagram 3 indicates the frequency with which rhythmic units occur in the Indian songs under analysis.

Having concluded the consideration of two melodic and one rhythmic peculiarity of Chippewa and Sioux songs, the writer would briefly describe a test of pitch discrimination made among Chippewa and Sioux during the summer of 1915. The principal purpose of the test was to determine how small an interval of pitch could be discerned by the Indians. The test was made by means of a set of eleven tuning-forks, the lowest or fundamental fork having a pitch of 435 vibrations (A above middle C, international pitch), and the remaining forks being tuned respectively ½, 1, 2, 3, 5, 8, 12, 17, 23 and 30 vibrations higher. Two forks were sounded in quick succession, and the Indian was asked to state which seemed to him to be the higher in pitch. Twenty-five Indians were submitted to the test, in which a wide variety of intervals was used. At the opening of the test it was presented in a simple form, the fundamental fork being followed by one having a tone 30 vibrations higher. The unhesitating reply was that the second was the higher tone. The test was then made more difficult; for instance, if an Indian showed a perception of five or six vibrations he was given series similar to the following: 8-3; 12-17; 12-8; 17-23. If he answered

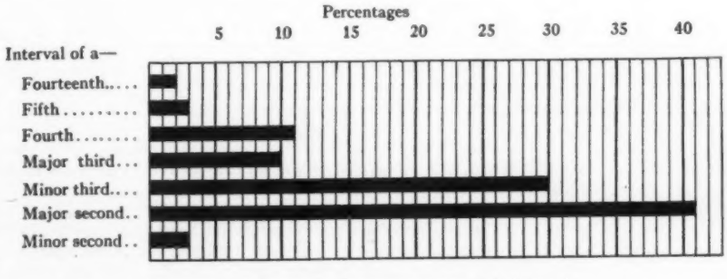


Diagram 2.—Frequency of occurrence of certain intervals

correctly in a majority of such sequences, the interval would be reduced. Many correct replies were given on intervals of one and two vibrations, and a few could discern the higher of two tones having an interval of only half a vibration. However, the lowest interval on which an individual Indian could be considered sure in his perception was three vibrations, or one-eighteenth of a tone. Others showed a limit in pitch discrimination of five vibrations, or one-eleventh of a tone.

The method used in these tests was that of Prof. C. E. Seashore, of the State University of Iowa, who kindly examined the record of the tests and expressed the opinion that the abilities shown by the Indians were about as good as would be found among average American whites under similar conditions.

This is a subject for further investigation, and is one of the many questions which open large and full of interest to the student of Indian music.

Light Projection*

A Short History of Its Evolution and Devices Employed

By C. A. Halvorson, Jr., and R. B. Hussey

LIGHT projection has been the subject of several papers within the last year or two and it would seem that the theoretical principles involved and the present practice had been well covered. Accordingly, something on the history and development of light projection or control of light may be of interest.

Any redirection of a beam of light is a form of control or projection. Such redirection may be accomplished by reflection or by refraction or both. In principle, both of these have been understood and to some extent used for many centuries.

The *Book of Job*, which is perhaps one of the oldest extant writings in the world, mentions molten lookingglasses or mirrors.

The Egyptian women in the time of Moses used mirrors in connection with the worship of their idols as well as perhaps for more secular purposes, and there are many specimens of brass mirrors still to be found in the museums.

One of the earliest mentions of the use of a lens is found in a play produced at Athens in 424 B. C., where Aristophanes alludes to the use of a burning glass in the following manner:

COMEDY OF THE CLOUDS.—Act 2.

Strepsiades—You have seen at the druggist's that fine transparent stone with which fires are kindled?

Socrates—You mean glass, do you not?

Strep.—Just so.

Soc.—Well what will you do with that?

Strep.—When a summons is sent to me I will take this stone, and placing myself in the sun, I will, though at a distance, melt all the writing of the summons.

(The writing was then traced on wax spread over a solid substance.)

Then there is a well-known tradition that Archimedes used mirrors to concentrate the rays of the sun, thereby setting fire to the Roman ships that were besieging the city of Syracuse in 212 B. C.

Euclid, the celebrated geometer, who lived in the third century, B. C., is credited with the authorship of a treatise on optics which takes up among other matters the reflection of light from concave spherical mirrors and alludes to setting fires by the sun's rays.

Another name that stands out prominently in the list of philosophers to study the subject of light and light control is that of Claudius Ptolemæus, better known as the Alexandrian Ptolemy. In common with most of these early philosophers, his chief interest was along the lines of astronomical research and his work on light was done with such investigations in mind. His writings on optics treat of the refraction of luminous rays in their passage through media of different densities. His measurements of refraction at different angles furnish the oldest extant example of an accurately conducted physical investigation by experiment.

Another prominent investigator was Alhazen, who lived in Arabia in the eleventh century, A. D. He evidently had access to the writings of Ptolemy and earlier astronomers and compiled their works, adding investigations of his own.

The manufacture and properties of simple lenses were beginning to be understood at this time, and from the work of Alhazen and that of Vitellio in Poland in the thirteenth century came the idea of using spectacles. It was not, however, until nearly the end of the thirteenth century that spectacles came into anything like common use.

John Peckham, Archbishop of Canterbury, who died in 1292, mentions mirrors made of steel, iron, polished marble and of glass covered on the back with lead. These last were made by pouring melted lead on hot glass plates. Mirrors of glass, coated with an amalgam of tin and mercury, were made by the Venetians in the sixteenth century.

Although the invention of the telescope has been claimed for several different men, it is probable that the credit should be given to Hans Lippershey, a spectacle maker of Holland, who described his invention and asked exclusive selling rights in 1608. Galileo heard of this invention and proceeded to make one himself the following year and later made numerous improvements in design.

Although many men had investigated the refraction of light, back as far Ptolemy, no one had recognized the fundamental law governing this phenomenon, until Snell, in 1621, succeeded in establishing the principle and expressing it in the form since known as *Snell's Law*, which states that the ratio of the sines of the angles of incidence and refraction is a constant for given media.

It is of peculiar interest just at the present time to remember that the German astronomer Hevelius, who died in 1684, invented a lens device for use in war, which he called a polemoscope and which was essentially the same as the trench periscope of today.

Huygens of Holland in 1678 was the first to express in definite form the wave theory of light. A few years later Huygens satisfactorily explained the principles of reflection and refraction. He also discovered polarization, but could not account for it. This same Huygens, it may be noted, manufactured lenses and telescopes and also, about the middle of the seventeenth century, invented the pendulum clock.

A history of the art or science of lighting would be incomplete without some mention of the work of Sir Isaac Newton (1642-1727). His most notable discovery was the composition of light and production of a spectrum by dispersion through a prism. At this distance it seems strange that he did not get a clearer idea of the nature of light, as he maintained to the last that light consisted of an emanation of material particles (the corpuscular theory). Newton also devised a method of studying the dependence of colors of thin films upon the thickness of the film and made, if not the first at least one of the first, reflecting telescopes. Probably this was the very first reflecting telescope to be used for actual astronomical work.

During the eighteenth century a number of developments in the theoretical investigation of light and in the design of optical apparatus were made.

As early as 1745, it is said that reflectors of some sort were used on street lanterns, and Lavoisier, the famous chemist and physicist, investigated the properties of such reflectors. The only mention of reflected light earlier than this that we have been able to find was the concentrating lantern alluded to by Pepys about the middle of the seventeenth century. It seems strange that some lens or reflector lighting units were not devised before this time, inasmuch as candles and oil lamps were in common use and the properties of simple lenses and concave reflectors were well understood.

Dollond in 1757 was the first to make and describe achromatic combinations of lenses by using glasses of different qualities, although the principle and some of the possibilities were described by a man by the name of Hall about twenty years earlier.

Lavoisier in 1774 made a lens of about 4 feet (1.2 m.) in diameter, using two concave glasses put together at the edges and filled with water or other fluids. With a lens of this type it was possible to not merely ignite wood in the sun's rays, but even to melt metals. Buffon made up a compound mirror of several hundred plane mirrors, each about 6 inches by 4 inches (15 by 20 cm.) mounted in a large frame so as to approximate a parabolic mirror. With this he succeeded in setting fire to wood at a distance of 210 feet (64 m.), demonstrating the possibility of Archimedes having set fire to the Roman ships in this manner. Buffon also proposed in 1748 to make a lens out of a solid piece of glass ground in steps or concentric zones so as to reduce the thickness to a minimum. This was similar to the designs worked out by Fresnel some 70 years later.

As early as 1763, parabolic reflectors consisting of small facets of silvered glass set in plaster of Paris were used in some of the lighthouses on the Mersey. Spherical metallic mirrors were introduced into France in 1781 and were followed by parabolic reflectors of silvered copper in 1790.

Fresnel, who began his optical work about 1814, introduced the conception of transverse light waves and harmonized the former theories and observed phenomena. He was able to explain reflection, refraction, polarization and interference on this basis. He also made notable advances in the art of reflector design and construction, working out the sectional lens-prism system bearing his name.

In 1825 Drummond conceived the idea of using as a source of light a piece of lime or similar oxide heated to incandescence in a blast flame. He finally worked out the "lime light," using an oxyhydrogen flame on a cylinder of lime and adapted the lamp to searchlight and stereopticon work. According to Professor Elihu Thomson, the first floodlighting was doubtless done about this time in theatres using units of this kind, although the first electric arc to be used in theatrical work is not recorded until 1846 in Paris. The first searchlamp to be used in war is said to have been a Drummond limelight outfit used in the attack on Fort Wagner, Charleston, in the fall of 1863.

In 1848 the first electric arc lamp for general illumination was installed in Paris, using a huge voltaic battery to supply the current. The public were amazed at the powerful clear white light, and many fanciful predictions were made of cities illuminated in the future by these lamps, and even a city lighted by a single lamp of immense candlepower suspended high in the air.

Soon after the middle of the century, the electric arc lamp was developed to a commercial point, providing a practical light source of high intensity and great brilliancy. This gave fresh impetus to the study and design of light-projecting apparatus. The arc searchlamp soon became a commercial article and has been improved and elaborated upon until at the present time arc searchlamps are available in many sizes and consuming from about 10 to several hundred amperes, with parabolic mirrors up to 6 or 7 feet (1.8 to 2.1 m.) in diameter, and giving light beams of hundreds of millions of candlepower.

The most notable advance of recent years in the design of arc searchlamps is due to Beck, who invented the intensive flame carbon arc searchlamp. In the endeavor to produce higher intensities by increasing the current through the arc, it was found that a very heavy current produced flaming and unsteadiness. The intense heat caused the carbons to crumble away rapidly unless a carbon of very large diameter was used, which produced unsteadiness of operation and poor focusing. By directing a stream of alcohol vapor or other non-oxidizing gas, the carbons could be kept cooler on the outside and prevented from wasting. This made it possible to operate much greater current densities and accordingly obtain much higher beam intensities. The light is further increased by the use of carbons cored with certain metallic salts and greater steadiness and uniformity is obtained by rotating the carbons.

In connection with the commercial development of the parabolic mirror, it was found that the manufacture of reflectors with a true parabolic curvature was difficult and expensive, while a spherical shape could be obtained much easier. Accordingly, Mangin in 1874 devised a reflector of glass in which both inner and outer surfaces were spherical, but of different radii, so that the reflector was thicker at the edge than at the middle. By proportioning the radii of curvature correctly, the refraction of light through the glass, made up for the spherical aberration from the surface and an approximately parallel beam of light resulted. These mirrors give fairly good results, but are not as true or as efficient as the parabolic mirrors, although much less expensive.

In the design of lighthouse equipment the results are usually attained by the use of carefully ground optical

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glass prisms or prism-lenses, after Fresnel's general plan, but much improved since his time. The optical system of a lighthouse unit consists of the central lens or set of lenses arranged in zones known as the dioptric system, and outside of these a set of prisms known as the catadioptric elements, which depend upon both refraction and total internal reflection. In some cases a set of totally reflecting prisms also is used on one side of the light source to reflect all the light emitted in that direction back through or near the source and increase the intensity in the opposite direction.

Several United States patents, issued in 1853 and 1859, relate to special arrangements of parabolic and conic reflectors and simple lenses, particularly for lantern work. A patent issued in 1859 discloses a combination of an ellipsoid with a paraboloid. A number of interesting arrangements of multiple prisms and reflectors are described in the patent to Skelton in 1872, while the patents to W. Wheeler in 1881 and 1882 show some peculiar and complex reflectors made by combining two or three conic curves in a single reflector. Unfortunately, little commercial success was realized from this work, largely perhaps on account of the fact that a concentrated focusing light source with satisfactory operation was not available at that time. Then, too, while the principles of light measurement were understood, the science of photometry was but little developed and the distribution of the flux about the common light sources was not known and little attempt had been made to utilize the largest possible proportion of the emitted light. Mention should also be made of the prismatic glass devices of A. P. Trotter, patented in 1885, and of Blondel and Psaroudaki in 1896, these representing the fundamental principles of the prismatic glassware now so commonly used.

Although floodlighting by the use of projector lamps with concentrating reflectors may be said in one way to date from the first commercial searchlamps, before the middle of the last century, it has not been practiced to any considerable extent, except for temporary and spectacular purposes, until the last two or three years. Occasionally some particular point of interest was temporarily illuminated, but little was thought of such illumination for continued operation. On the occasion of a celebration in London, in February, 1872, an attempt was made to illuminate the dome of St. Paul's Cathedral by the use of a large number of ship lanterns, but the result was very unsatisfactory. Commenting on this, a London magazine made the following statement:

"Perhaps the most practicable way of effectually illuminating St. Paul's would consist in flooding it with electric light projected from various quarters."

Considering the illumination of a monument, Dr. Louis Bell writes, in 1902, as follows:

"About the only way of getting any effective illumination at the top of the monument is to use focusing lamps with projectors. Three or four of these mounted symmetrically about the object to be lighted at any convenient distance will come as near an effective illumination as one may expect to get. Their beams should be inclined upwards enough to keep them effectively out of the field of vision and the rest of the monument, if of light stone, should be left to itself. A figure wholly light in tone can be very beautifully illuminated by such means, but if of bronze or similar dark material, *e. g.*, the great Bartholdi Liberty, adequate illumination is both very difficult and, if successful, decidedly expensive."

The last sentence is of peculiar interest in view of the recent illumination of this same Statue of Liberty with a permanent installation of incandescent projectors.

In the summer of 1906, W. D'A. Ryan conducted numerous experiments at Nahant, Mass., along the lines of spectacular lighting of clouds of steam, presaging the color scintillator used later at the Hudson-Fulton Celebration and at San Francisco, also illuminating a large American flag suspended over a street, using a battery of about ten arc searchlamps. The following year Ryan installed a large battery of these searchlamps at Niagara, illuminating both the American and Canadian Falls. Colored screens in front of the projectors provided a means of obtaining a wide variety of color effects at will, and the whole resulted in a very unique and pleasing display. As early as 1908, the tower of the Singer Building in New York City, the loftiest city building in the country at that time, was illuminated by Ryan by means of arc searchlamps.

Although the best results from the point of view of intensity and color have been obtained with arc lamps and arc projectors, the complication and the necessity of an electrically-operated mechanism or of manual control of some sort makes such a system too expensive for common use.

Three factors in particular served to prepare the way for general floodlighting. The first of these was the installation of ornamental magnetite arc lamps in New Haven, Conn., in 1911; the first intensive downtown lighting or "white way" system adopted in this country or elsewhere. With this system not only was the street lighted to a relatively high intensity without glare, but the building fronts and façades and cornices of nine-story blocks were beautifully illuminated in all their details.

The second factor was the wonderfully beautiful lighting effects produced by W. D'A. Ryan at the San Francisco Exposition by the use of powerful light sources, arc, incandescent and gas, with and without reflectors; but every brilliant source was screened from view, the entire Exposition being painted, as it were, with light from invisible sources.

And third, the introduction of the concentrated filament gas-filled incandescent lamp, making possible the development of simple efficient and easily handled projector units of comparatively low cost. The first floodlighting projectors using these lamps were made little more than two years ago, and many designs and different forms and sizes have been developed and used since that time.

With the exception of this gas-filled concentrated filament incandescent lamp, the other raw materials now available to the designing engineer are the same as for a number of years past. The chemical deposition of silver on glass replacing the mercury-tin amalgam dates back to 1843, while sheet aluminum has been used for about 25 years.

In projection of light or light control, almost any desired effect or kind of distribution can be produced if the purchaser is willing to pay for it. Polished lenses are used in cases where the greatest accuracy or maximum effect must be had, as in telescopes and the like, also in lighthouses and to a great extent in stereopticon work. Optically ground and polished prisms are also used in lighthouse work. A cheaper grade of prisms, known as holophane, pressed, but not ground, yet of high transmission, are used extensively in street and interior illumination, where the cost is a considerable factor and where the greatest accuracy is unnecessary. Pressed glass, silvered, is also used in large quantities in interior lighting. Many different materials are used for reflecting surfaces by different designers, such as aluminum, nickel, silver and gold plate, silvered glass, aluminum bronze paint, porcelain enamel and even flat white paint. Then, too, the designer of present day lighting projectors may use at will any of the conic sections as parabola, hyperbola, ellipse, circle or any combination of these, in the design of a reflector, or even an arrangement of many small plane mirrors placed so as to roughly approximate a given curve. This last serves to spread the light more widely and also more uniformly than a single, simple curve would do using ordinary commercial materials.

The automobile headlamp is another phase of light projection upon which much time and energy has been devoted during the last few years. Much work has been done by persons apparently unacquainted with the principles of light control, resulting in many inefficient and theoretically incorrect devices. Every known optical principle has been used in the attempt to accomplish a very simple result. It may be said in this connection that if it could be definitely agreed just what lighting effect would be the most satisfactory and desirable, a device could be made to produce that effect. There are today many opinions on this point and accordingly many devices on the market.

Aside from whatever is accomplished with the automobile headlamp, there is an obvious solution of the problem which apparently has escaped the majority of illuminating experts, namely, the illumination of the roadway. Considering Massachusetts alone, a rough computation shows that the same lumen output, or the same generating capacity as is now used for automobile headlighting, if used for street lighting, would illuminate approximately 10,000 miles of highway to a fairly satisfactory degree. These results could be accomplished only through the principles of scientific projection, and this point is mentioned here only to give some idea of the possibilities of development along these lines. If the same expenditure of human effort and money were directed toward the accomplishment of this most desirable result as have been expended on futile attempts to meet the Massachusetts headlamp law, all maintenance costs and similar matters doubtless would be settled.

Signaling by means of ground and polished parabolic mirrors used in conjunction with highly concentrated filament incandescent lamps is beginning to be of importance, also the use of projection devices in aerial and trench warfare, for which purpose large numbers of searchlamps of different kinds are now being used abroad.

In the development of mirror backings, one notable feature already has been accomplished, that is, the electrolytic deposition of copper over the silver for protection and for increasing the heat radiation.

The illumination of advertising matter presents another large field for scientifically designed projection, and without doubt much will be accomplished in this direction. In street lighting, too, further improvements may be expected, especially along the lines of prismatic control of light. The lighting of many large outdoor areas will in the future undoubtedly be accomplished by means of large sources of light used in conjunction with reflectors or prismatic glassware, or combinations of both, affording opportunity for the illuminating engineer to employ all his skill.

It is reasonable to suppose that advance in the art of interior illumination may be effected through the medium of improved projection apparatus. While nothing of a permanent nature other than the well known indirect system has as yet found favor, there is food for thought in the lighting of interiors by projection.

DISCUSSION.

W. D'A. Ryan (communicated): I have reviewed the paper on "Evolution of Light Projection," by Mr. C. A. B. Halvorson and Mr. R. B. Hussey with profound interest, and wish to add my congratulations to Messrs. Halvorson and Hussey and to the Society in securing this contribution. There is very little that I could add of importance.

While it is clearly not the intention of the paper to go into details in reference to installations, nevertheless it may be interesting to know to what extent projectors were used in some of the notable installations mentioned.

The Singer Tower illumination in 1908 was produced with thirty 18-inch arc projectors on the facades and one 30-inch arc projector on the flag. At Niagara Falls in 1907 the total beam candlepower for the various arc projectors used was approximately 1,115,000,000. At the Hudson-Fulton celebration, 1,000,000,000. The Electric Steam Color Scintillator at the Panama-Pacific International Exposition was 2,600,000,000. In 1912, the Buffalo General Electric Company's building was illuminated by direct diffused luminous arcs on the facades and three 30-inch arc projectors were mounted in the cupola on a revolving platform. Each projector rotated automatically to the right or left through a series of colored gelatine disks, producing a very dignified and impressive spectacle.

The first attempt at the use of incandescent projectors in quantity was in connection with the Panama-Pacific International Exposition. While these were not in operation until 1915, they were designed especially for this work in the fall of 1912. Approximately 300 flags were illuminated on the main group of buildings. One hundred with 13-inch arc projectors, and 200 with 500-watt incandescent projectors. In addition, there were 251 Seraphic Figures illuminated with 100-watt concentrated filament incandescent projectors. The balance of the projectors at the Exposition consisted of two hundred 18-inch arcs, twenty-five 30-inch arcs and forty-eight 36-inch arcs. This shows to what a great extent the projector was used in combination with other lighting units.

Another notable use of projectors was the illumination of the 90-foot Municipal Christmas tree with evergreen and bunting semi-circular background, in Chicago in 1915 and 1916. Both arc and incandescent projectors were combined and the tree was lighted alternately both in white and colors. Action was added to the spectacle by the use of 4,000 Novagem jewels taken from the Tower of Jewels at the San Francisco Exposition. The effect was wonderfully impressive.

Tanning Fishing Nets

An account of the methods employed by the Dutch fishermen for preserving their nets. The usual procedure is to immerse the net in a hot solution of tannin for some time, and then to dry it. The author has found that if the net is then immersed for 15 minutes in a solution containing 1 per cent of copper sulphate and 0.7 per cent of ammonia, and again dried, the durability is much increased. After this treatment, it is important for the net to be used for fishing as soon as possible. The method is also adapted to the preservation of other forms of netting.—W. Tombrock in *Chem. Weekblad.*

Notes on Road Building in Washington's Time*

By A. N. Johnson, M. W. S. E.

ROAD building, as we know it to-day, did not begin in the United States until after the Revolutionary War. Prior to that time the work that had been done was chiefly in opening and marking trails, at first for pack animals only, later widening these to accommodate wagons. In 1750 routes were authorized to be laid in Central New York and Pennsylvania merely to accommodate pack horses.

In many sections the location of the trails and the roads following them were notable in that they kept to the highlands or the ridges. When it was necessary to cross a stream the road would follow the ridge as far as possible, then make a sudden dip. As a consequence, at the stream crossings the grades were excessive, far more than the general contour of the country would demand. This feature of road location is particularly noticeable in Maryland and Virginia.

The administration of the roads in colonial times was at first in the hands of the individual settlers and later was placed under the auspices of the various towns, plantations or parishes, in general being patterned after the English system, which it might be said, in passing, was at this time about as wretched as it could well be.

The year 1775 saw the beginning of corduroy roads and it is remarked that this was a work "that was done by everybody in particular and by nobody in general." A traveler would become stuck in the mud and would build a short bit of corduroy road to help himself out, which was left there for the benefit of other travelers.

Harriet Martineau remarks that "corduroy roads appear to have made a deep impression upon the imagination of the English, who seem to suppose that all American roads are of corduroy. I can assure you that there is a large variety of American roads * * *

"Lastly, there is the corduroy road, happily of rare occurrence, where if the driver is merciful to the passengers he drives them so as to give them the association of being on the way to a funeral. There are involuntary sobs on each jolt helping the resemblance. Or, if he be in a hurry he shakes them like pills in a box."

Until 1790 there were not to exceed 1,800 miles of post roads in the United States. It was about this period that broken stone or macadamized roads were first built. Successful roads of this construction were in use a number of years before they were introduced into England by Macadam in 1816. Macadam came to England from America in 1783 and was no doubt acquainted with the progress made in the United States in this form of construction.

One of the earliest macadamized roads was in Pennsylvania, the Philadelphia-Lancaster turnpike, which was completed in 1794 at a cost of $465,000.

The president of this turnpike company issued in 1796 the following notice to the public: "Be it further enacted by the authority of the aforesaid that no wagon or other carriage with wheels, the breadth of whose wheels shall not be four inches, shall not be driven along said road between the first day of December and the first day of May following in any year or years, with a greater weight thereon than 2½ tons."

There is a record of an earlier turnpike in Virginia built in 1785-86. This road connected Alexandria with the lower Shenandoah.[1]

The importance of road communication between the Ohio country and the East was early appreciated and was constantly in the mind of Washington, to whom is attributed, more than to anyone else, the attainment of the great highway across the Alleghenys. A connecting link in this route was from Fort Frederick to Fort Cumberland. Fort Frederick was erected in 1756 and the necessity for a short route from Fort Frederick to Fort Cumberland soon became apparent. After the capture of Fort Du Quesne a committee of the Maryland Assembly was ordered to make a report of the cost to connect Fort Frederick and Fort Cumberland by a wagon road. The following extract is taken from this report:

"Your committee have made an Enquiry into the situation of the present wagon road from Fort Frederick to Fort Cumberland, and are of the opinion that the distance by that road from one fort to the other is at least eighty miles, and find that the wagons which go from one fort to the other are obliged to pass the Potomac River twice, and that for one-third of the year they cannot pass without boats to set them over the river.

"Your committee have also made an Enquiry into the conditions of the ground where a road may most conveniently be made to go altogether upon the North Side of the Potomac, which will not exceed the distance of sixty-two miles at the expense of £250, current money, as may appear from the following estimate, viz.:

"An estimate of the expense of clearing road from Fort Frederick to Fort Cumberland, and the several different stages:

For clearing from—	£	s.	d.
Fort Frederick to Licking Creek, 3½ miles	0	0	0
Licking Creek to Praker's Creek, 8½ miles	12	0	0
Praker's to Sideling Hill Creek, 12 miles..	16	0	0
For a bridge over Sideling Hill Creek....	60	0	0
Sideling Hill Creek to Fifteen Mile Creek, 4 miles	22	0	0
Fifteen Mile Creek to Town Creek, 15 miles 140	0	0	
Town Creek to Col. Cresap's, a good road, 4 miles	0	0	0
Col. Cresap's to Fort Cumberland, wants clearing, 15 miles.....	0	0	0
	250	0	0

"Your committee are of the opinion that a road through Maryland will contribute much to lessen the expense of carrying provisions and warlike stores from Fort Frederick to Fort Cumberland, and will induce many people to travel and carry on a trade in and through the Province, to and from the back country."

The first road to be built across the mountains was constructed by Washington as far as the Great Meadows. Washington had been placed second in command to Colonel Fry on an expedition sent out by the Governor of Virginia, November 15, 1753, with a letter to the French Commandant of the Fort erected by the French on the Ohio River. Colonel Fry was killed by a fall from his horse, which left the full responsibility of the expedition on Washington, who was barely twenty-one years old. He proceeded to Wills Creek, Maryland, and in his journal he describes this section of the road "the worse road that was ever traveled by man or beast."

From Winchester to Wills Creek, Washington was obliged to build the roads as he went to make them passable for his horse and wagons. Beyond Wills Creek he built a road, the route for which had been worked out by Col. Cresap three years before. This section of the road was known as Braddock's Road.

The writer walked over the portion of this road over Wills Mountain during the summer of 1899 and its course could readily be followed although much overgrown with brush and many trees of considerable size. This was the only road to the West until 1818, being in use for sixty-five years. The National Road opened in 1818 was relocated around the end of Wills Mountain, following the course of Wills Creek and eliminating entirely the steep grades of the route followed by Washington. It is probable that at that time he considered the obstacles to be met in following along the creek greater than going directly over the mountain, which route was through a saddle-back and was the most available of any direct crossing.

The following description, by a writer of the times, of the early work on the National Road begun shortly after Washington's death is of interest:

"That great contractor, Mordecai Cochran, with his immortal Irish brigade—a thousand strong, with their carts, wheelbarrows, picks, shovels and blasting tools, graded the commons and climbed the mountain side, leaving behind them a roadway good enough for an emperor." This road, called the "Chain of the Federal Union," was perhaps nearer to the heart of Washington than any other public enterprise of the time."

At the time of Washington's death the era of turnpike building was well under way, and for nearly forty years thereafter the method by which most of the important road work of the time was financed and administered was by private turnpike companies.

The amount of travel that many of the earlier roads carried was remarkable. On the Mohawk Turnpike from Albany west to Utica, began in 1787 and finished in 1800, a steady stream of settlers flowed westward from New England. Great wagons filled the road. Within 50 miles of Albany there were 52 taverns, but these could not provide sufficient accommodations.

The construction of the great westerly route from Baltimore through Frederick, Hagerstown and thence to Cumberland, was begun in 1787 by the counties but was turned over to private control in 1804 when the road was completed at the expense of certain Maryland banks. The travel was so great that it proved to be a wonderfully profitable investment, yielding 20 per cent. for several years.

After 100 years we see to-day another era of building long stretches of road, but financed and administered by the States. These roads will add to and strengthen the "Chain of Federal Union" so well begun by Washington.

*A paper presented before the Western Society of Engineers, and republished from the *Journal* of the Society.

Notes for this paper were compiled from "Historic Highways of America," by A. H. Hulbert, 1902-1905, Arthus H. Clark Company, Cleveland, Ohio, Maryland Geological Survey Report for 1899, "Highway Legislation in Maryland," by St. George L. Sioussat, and "Stage Coach and Tavern Days," by Alice M. Earle, 1900, McMillan & Company, New York.

[1] "Stage Coach and Tavern Days," Earle, p. 282.

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